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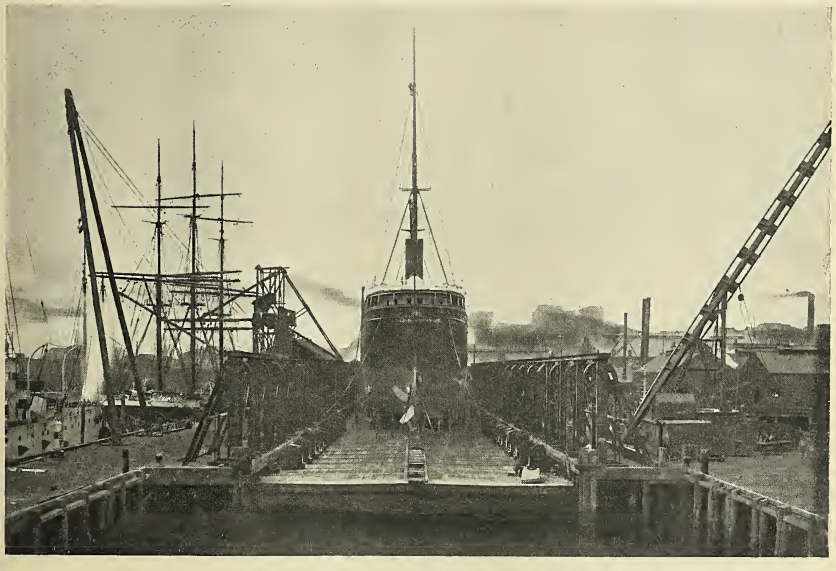
HYDRAULIC LIFTING DRY DOCK AT UNION IRON WORKS, SAN FRANCISCO.

One of the unique features of the equipment of the Union Iron Works, at San Francisco, is their hydraulic lift dock. When the works were moved to the present location, some years ago, one of the objects in view was to meet the demands of an increasing steamship trade, both for the repairing of old work and the building of new. Naturally one of the first requirements was a dry dock. A large portion of the dock work at San Francisco was at that time, and is at present, for the purpose of cleaning and painting, which, for most vessels, does not take more than one day. Speed in getting the dock and ship dry was therefore of prime importance. As the location of the dock was on a mud flat, with a depth of mud from 80 to 90 ft., it was seen at once that a graving dock would be a very difficult and disagreeable dock to clean, and very slow to dry. The mud, which is soft, would wash in every time the dock was opened, the tide at certain times being particularly favorable for that purpose. After a careful consideration of the requirements, and the many difficulties of construction, it was decided to build a lift dock, from the designs of G. W. Dickie, manager of the works.

This dock consists of a platform 62 ft. wide and 435 ft. long, made of steel girders, and raised and lowered by means of hydraulic rams, placed in a row along each side of the platform, as shown in the accompanying drawings. This platform carries the keel blocks, and is fitted with sliding bilge blocks, which can be operated from the surface. In operation the platform is lowered down, the vessel run in over the keel blocks, and the platform is then raised until the blocks touch the ship. The bilge blocks are now slid in until the ship is perfectly cradled, and the platform is moved up again,



WATER FRONT VIEW OF HYDRAULIC LIFTING DOCK AT UNION IRON WORKS—S. S. COLON DOCKED.

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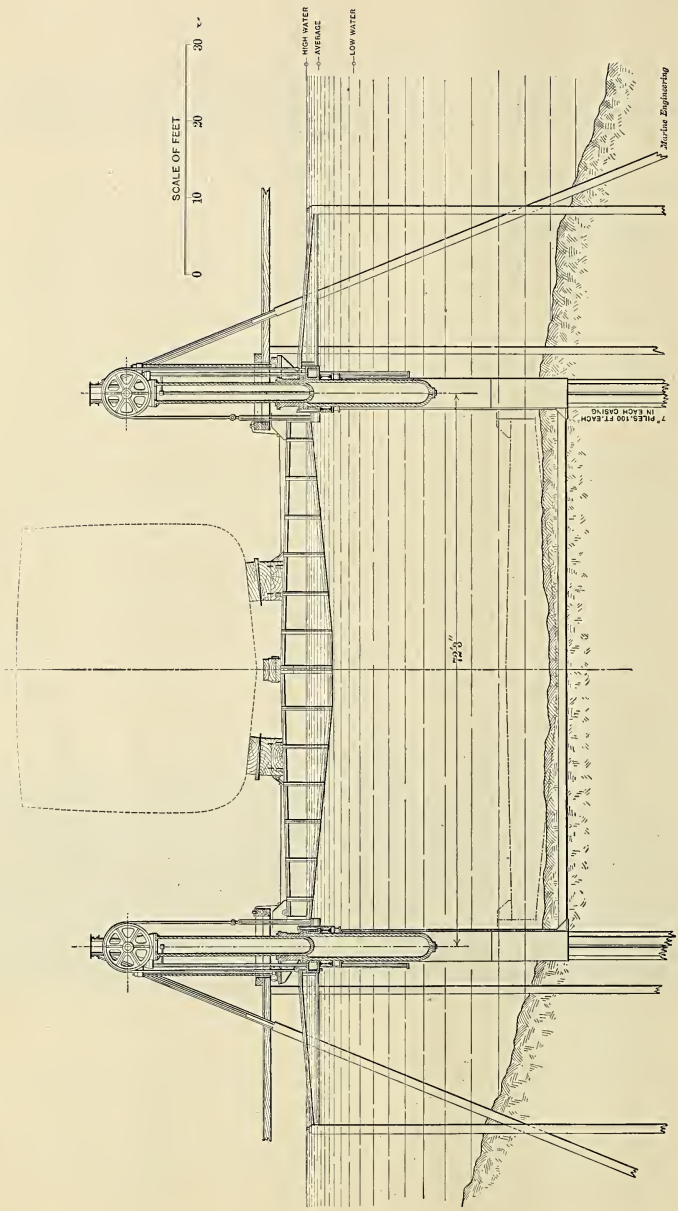
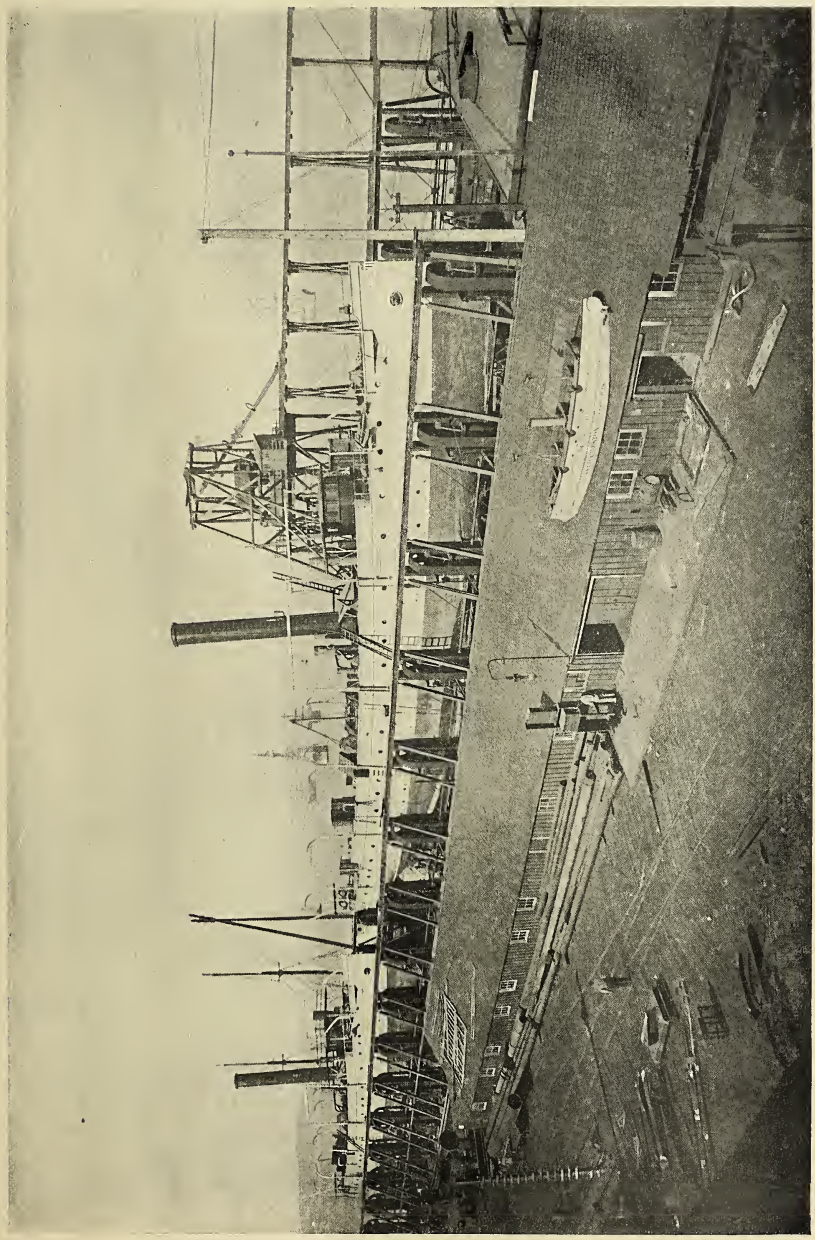
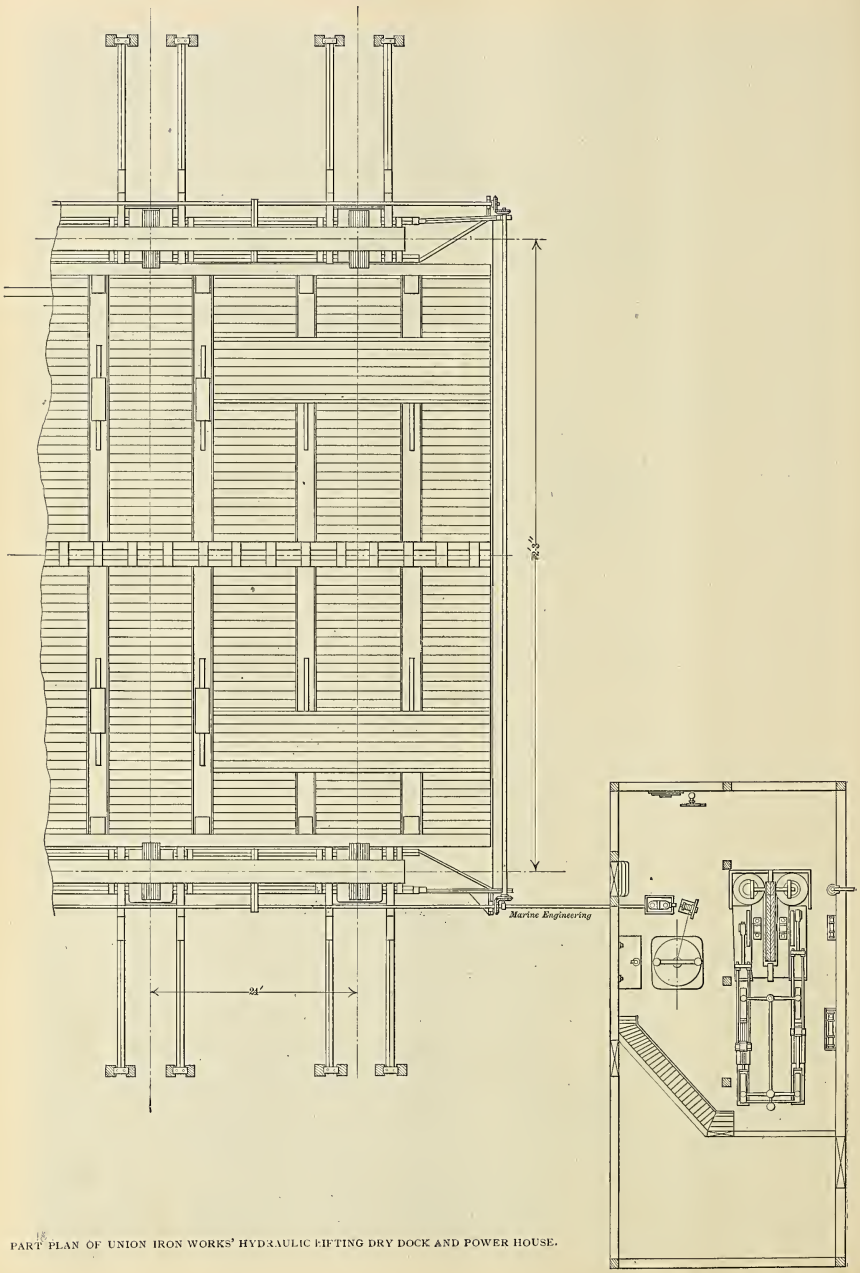


CROSS SECTION OF HYDRAULIC LIFTING DRY DOCK IN THE SHIP YARD OF THE UNION IRON WORKS, SAN FRANCISCO, CAL.



PHOTOGRAPH OF HYDRAULIC LIFTING DRY DOCK AT THE SHIP YARD OF THE UNION IRON WORKS, SAN FRANCISCO, CAL.—U. S. GUNBOATS WHEELING AND MARIETTA ON DOCK.

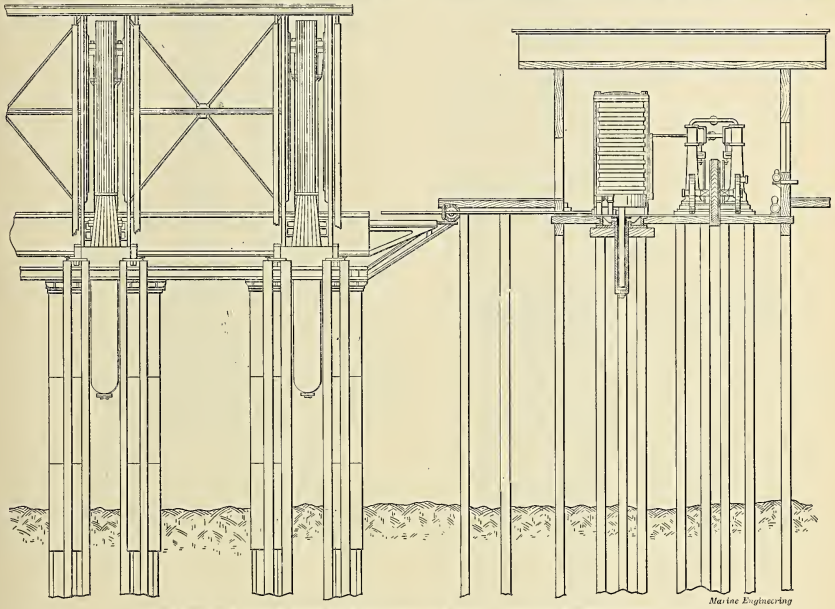


PART PLAN OF UNION IRON WORKS' HYDRAULIC LIFTING DRY DOCK AND POWER HOUSE.

bringing its surface well above that of the water. This raises the ship clear above the water, where wind and sun rapidly dry the bottom. The platform itself is hosed off clean, and is as dry and comfortable to work on as could be desired. The rams, of which there are eighteen on a side, are 30.7 in. dia., and have a lift of 16 ft. At the upper end of each ram there is a rope sheave, 6 ft. dia., over which are passed eight steel cables, 2 in. dia. Each cable has been tested with a load of 80 tons. The outer ends of these cables are made fast to the foundation plates, and the inner ends to the longitudinal side girders of the platform. This arrangement gives the platform a lift of 32 ft. for 16 ft. lift of the rams. The depth of water over the keel blocks, at ordinary high water, is 22 ft. The upper ends of the rams work in vertical guides, held in place by, girders, and passes down between the foundations, as shown.

The lifting power is obtained from two double horizontal plunger pumps, having pistons 3 3-4 in. dia. and stroke of 36 in. They are driven, through gearing, by two vertical engines, with cylinders 12 in. dia., by 16 in. stroke of piston. The steam pressure is 90 lbs. per sq. in., and the maximum hydraulic pressure is 1,250 lbs. per sq. in. With this maximum pressure, the speed of the loaded platform is 3.2 in. per min. An accumulator is attached to the pump line, having its weights so arranged that the pressure on the dock rams is increased in proportion to the load on the platform.

When the platform is up, a line of locks, thirty-six on each side, is slipped under the edge by means of a hydraulic cylinder, the platform is then lowered until

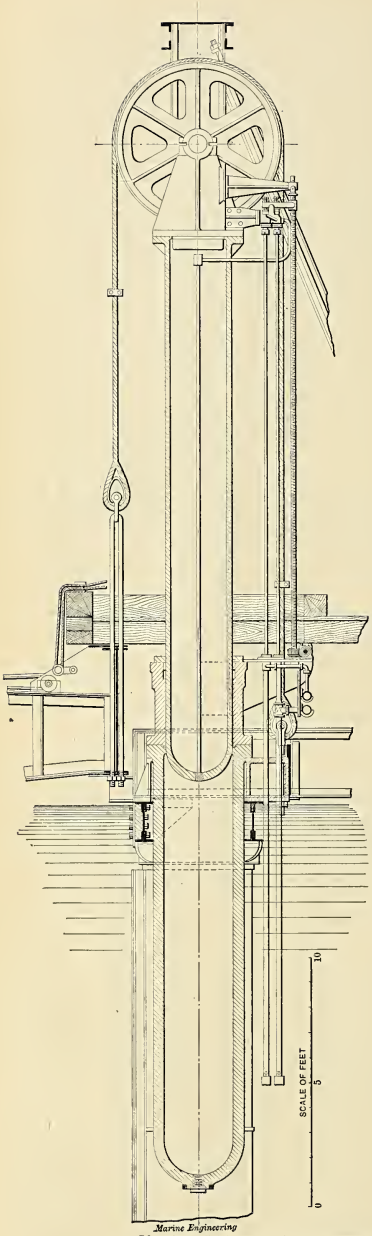


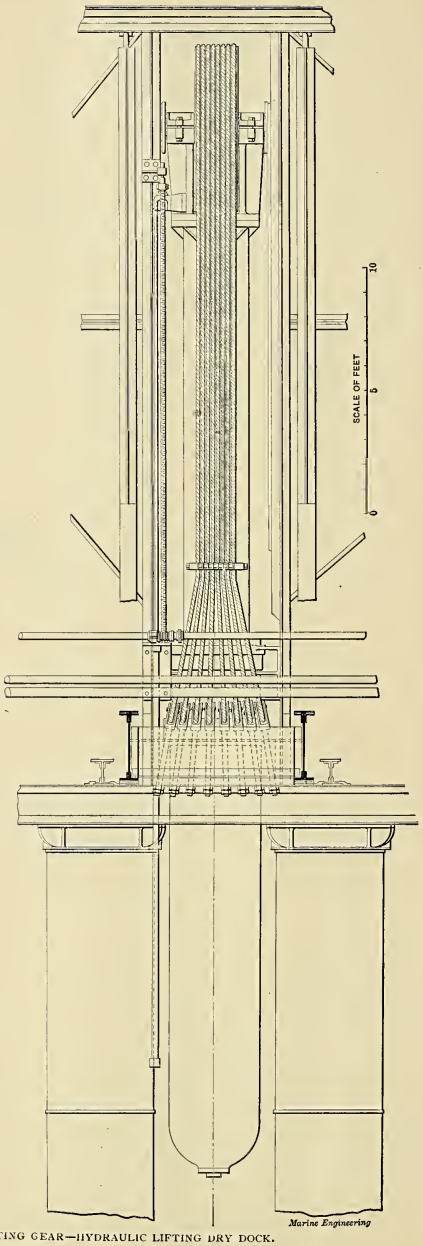
PART SIDE ELEVATION HYDRAULIC LIFTING DRY DOCK—SHOWING POWER HOUSE ALSO

and forming part of, an iron superstructure, which runs the entire length of the dock. This superstructure is supported laterally by stays made fast to anchor piles, as shown in the drawings here published. The rams and cylinders are made of cast iron.

The foundations were not the least difficulty that had to be overcome. It was desired to rest the dock on piles; but the teredo is very destructive to piling on the Pacific coast. A group of piles, close together, was therefore driven at each foundation and covered with a cylindrical iron casing, extending down below the mud line. The piles fill the cylinder completely, and no pile is shorter than 90 ft. Two of these foundations were built for each hydraulic cylinder, which is supported from the top of the iron pile casings, by means of cross it rests upon them, and remains there while work on the ship is going on. When the vessel is ready for sea again the platform is raised a little, the locks are withdrawn and the platform lowered. While the platform rests on these locks, the accumulator is so attached to the pump engine as to maintain, automatically, pressure enough on the pipe line to supply waste and keep the cylinders full, but not enough pressure to raise the platform off the locks.

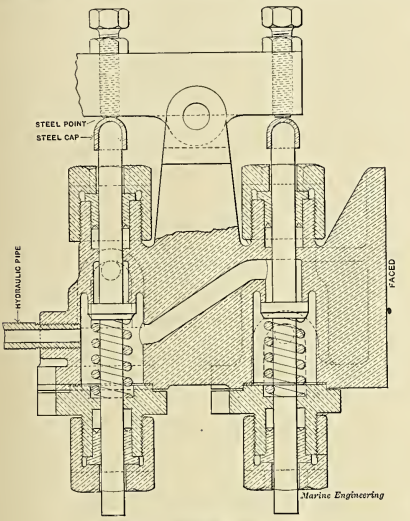
It is, evidently, impossible to distribute the weight of the platform and vessel evenly on all the rams, and even if that were possible the friction on the rams would not be the same, so that some of the rams would rise faster than others if means were not provided to prevent them doing so. For this purpose Mr. Dickie





DETAILS OF HYDRAULIC CYLINDERS AND LIFTING GEAR—HYDRAULIC LIFTING DRY DOCK.

designed the special distributing valve, shown in section on this page, and a special valve gear for operating the same. One of these valves is attached to the top of each ram, the feed and exhaust pipes sliding up and down through stuffing boxes in the foundation plates. Referring to the sectional drawing of this distributing valve, the small poppet valve on the right hand is the feed valve, while that on the left is the exhaust. These valves, as can be seen, are partially balanced and open against the pressure in both cases. They are thus self closing; although an auxiliary spring is also provided to assist in closing, thus securing more positive action. The delivery opening is shown at the left side of the valve. The 1-2 in. hydraulic pipe passes from this into the interior of the ram, near the top, goes down its center, and delivers into the cylinder through the bottom of the ram. The differential valve lever, also shown on the same drawing, is connected, at its outer end, by



HYDRAULIC DISTRIBUTING VALVE.

means of a nut to a vertical screw. This screw, in turn, is connected by worm gearing to a horizontal shaft, that runs down the side of the dock, the shafts on each side being rotated in unison by a small reversible engine in the power house. This construction is clearly shown in the accompanying drawings. When this rotating engine is started in the direction for raising the platform, the outer end of the differential lever is raised, the feed valve is opened a little, and the ram starts upward; and, as long as the ram continues to move upward as fast as the nut, the feed valve will remain slightly opened. Should it move faster than the nut, it will first allow the feed valve to close; and if it should still continue to move in advance, as might occur through excessive leakage of the feed valve, the exhaust valve will open, effectually checking the motion. Should the ram lag behind the nut, the feed valve will be opened wider and wider, until the supply is sufficient to force the ram up to its proper place. Means of adjustment are provided, and the distance which the ram can move ahead, or fall behind, is very small. Since every nut travels upward at the same speed, the rams all move in unison, and the floor of the platform remains in one plane, no matter how unevenly the load may be distributed. To lower the platform, the rotating engine is reversed, the action of the distributing valve being similar to that in going up, and the water in the cylinders is returned to a tank, from which it is used again in raising. The mechanism has worked exceedingly well, the dock having been in continuous service without mishap since its construction, twelve years ago.

The accompanying illustrations show the United States gunboats *Marietta* and *Wheeling* on the dock together, and also the Pacific Mail steamer *Colon*, as seen on the dock from the water front.

The main dimensions and principal data are as follows:

Total length of longitudinal girder	421 ft. 7 in.
Total length of platform on the keel	436 ft. 6 in.
Width of platform	65 ft. 7 in.
Maximum lift	32 ft.
Maximum lifting capacity	6,000 tons.
Maximum lifting capacity per ram	1664 tons.
Number of rams	36
Number of foundation columns	72
Distance between centers of rams lengthways	24 ft. 0 in.
Distance between centers of rams crossway	72 ft. 3 in.
Diameter of plungers	30.7 in.
Eight 2 in. diameter steel ropes per ram.	
Two 12x16 vertical steam engines for pumps.	
Four pressure pumps, 36 in stroke; diameter of plungers of same	3 3-4 in.
One duplex 6x6 in. reversing engine for rotating valve shafts.	
One Worthington Duplex pump	4 1-2x1 3-8x4 in.
One accumulator 8 in. dia. of ram 48 in. stroke.	
Weight of ram head	12,000 lbs.
Weight of 11 pieces (adjustable weights)	47,500 lbs.
Weight of ram	2,500 lbs.
Total weight of ram and weights	62,000 lbs.
Average speed of pressure pumps 31 strokes per min.	
Pressure for lifting { empty dock 275 lbs. per sq. in. / loaded dock 1,250 lbs per sq. in.	
Speed of loaded platform with 1,250 lbs. pressure per sq. in. on rams, 3.2 in. per min.	
Steam pressure, 90 lbs. per sq. in.	

We are indebted to the Union Iron Works and George W. Dickie, manager, for the data and drawings, which were courteously placed at our disposal.

A pretty incident is related as having occurred at the launching of the S. S. *Augusta* from the yard of Neafie & Levy at Philadelphia, recently. Just as the new vessel commenced to move, the sponsor, Miss Jane H. Andrews, attempted unsuccessfully to break the customary bottle of champagne. In this emergency Miss Andrews plucked an American beauty rose from her corsage bouquet and, flinging it against the bow, christened the vessel.

For the convenience of vessels in Asiatic waters a new dry dock has been established at Shanghai, China, of the following dimensions: Length on blocks, 540 ft.; width at entrance, 80 ft.; depth of water over sill at ordinary spring tide, 24 ft. The shops adjoining the dock have been fitted with modern machinery for repair work. Among the vessels recently docked there was the North German Lloyd steamship *Konigsberg*, of about 7,000 tons load displacement.

A new floating dry dock for the port of Havana, to replace the one installed by the Spanish Government, and subsequently sold for removal to Vera Cruz, is among the probabilities of the future.

COMPARISON BETWEEN PERFORMANCES OF TWO SEA-GOING STEAMSHIPS.*—I.

BY J. D. M'ARTHUR, MEMBER.

While the author was relating his experiences in two steamers, belonging to different owners, it was suggested that the results, put in the form of a paper, might prove of interest to the Institute of Marine Engineers, contrasting as they do the economical working of a carefully designed ship and engines, with the performance of one built to sell and bought off the stocks.

The first steamer I will term A, the second B; and it may be mentioned that, between two sister ships, built to the specification of A, the difference of performance was very small, the second of the two possessing a fraction of a knot more speed, due to a slight alteration in the propeller, after experience acquired with the first.

The leading dimensions and particulars of machinery of the vessels undergoing comparison are as follows:

PARTICULARS.	A	B
Length between perpendiculars	392ft.	350ft.
Beam	46ft. 6in.	41ft. 6in.
Load draught	25ft. 4in.	24ft.
Nett registry tonnage	2,850	2,100
Dead weight capacity	6 800	5,200
Diameter of cylinders	27in., 42in., 69in.	24in., 39in., 64in.
Stroke of pistons	54in.	45in.
Revolutions at usual speed	57	61
Average I.H.P.	1,440	1,180
Diameter of propeller	18ft. 6in.	16ft. 6in.
Pitch do	18ft.	17ft. 6in.
No. of boilers and pressure	2—160lb.	2—170lb.
Mean diameter and length of do.	15ft. 3in. by 12ft.	14ft. 9in. by 11ft. 6in.
No. and diameter of furnaces	3 each, 3ft. 9in.	3 each, 3ft 6in.
Type of donkey boiler	Marine	Marine
Diameter and length of do.	9ft. 6in. by 11ft.	8ft. 6in. by 8ft
No. and diameter of furnaces	2—34in.	2—2ft. 7½in. at mouth, 2ft at back
Nature of draught	Howden's forced	Howden's forced
No. and size of winches	7—8in. cylinders	6—7in. cylinders
Dimensions of fan engine cylinder	8in. by 12in.	8in. by 12in.
Dimensions of electric cylinder	8in. by 12in.	——
Revolutions of electric engine.	200	——
Do. dynamo	600	——
Average output of do.	5,000 watts	——
Type of feed pumps	Weir's	Ordinary ram
Do. do. heater	Weir's	Morison's
Do. evaporator	Weir's	Morison's
Steering engine	Caldwell, 8in.	Caldwell, 7in.
Total No. of auxiliary engines, including pumps, ash hoists, winches	17	10
Average speed	9 knots	8.75 knots
Do. daily consumption of good Welsh coal	19 tons	21.5 tons
Do. consumption per I.H.P. per hour	1 23 b.	1.7lb.
Do. consumption per ton carried per mile	0316lb	.0485lb.
Date of launch	June, 1894	November, 1894

The figures in the last line but one are sufficient evidence that the saving effected by A, in comparison with B, would in a very short time write off, not only the interest on the extra cost, but the principal as well. In the case of A, it will be observed that, in addition to the main engines, steam had to be supplied to Weir's pump and evaporator, the fan engine, steering engine, electric engine (13 hours per day), ash-hoist (every watch), and in working out the lb. per I.H.P. no allowance is made for this, so that these (A) ships may fairly be classed amongst the most economical afloat.

* Read before the Institute of Marine Engineers, London, England.

The designs for these (A) ships emanated from one of the best-known marine engineer superintendents on the Clyde, and the arrangement throughout was as near perfection, in my opinion, as need be.

The usual H.P. piston-valve was done away with, and an ordinary double-ported slide-valve fitted, without relief-ring or any means of reducing the pressure between the faces, both of which were composed of special hard iron. At first oil was admitted with the steam by means of the sight-feed lubricator; but, there being no filter fitted, this soon caused trouble in the boilers, though, strangely enough, so far as could be seen, the surfaces of the condenser tubes did not appear to be much affected. It was then determined to try to run without any oil, except so much as got in with the piston-rods from swabbing; and, so far as valve-faces were concerned, this was done—with no bad results, while, of course, there was a saving of several days' work in the boilers every time they were opened, scraping grease off shell-plates, furnace-bottoms, combustion chambers, bottoms and tubes.

Buckley's springs were fitted to all the pistons, and the cylinders were in beautiful condition, the tool-marks being quite perceptible at the end of two years. The H.P. cylinder alone was fitted with a loose liner. The indicator cards, taken at ordinary sea speed—9 to 9 1-2 knots—from the H.P. engine, showed that this was not the most economical speed, for the expansion being run almost hard in, excessive compression and wire-drawing took place, consequent on the method adopted of diminishing work lost by friction by reduction of travel and size of valve, the former being only 4 1-2 in. and the maximum port opening to steam 15-16 in. each port.

The feed water was heated to a temperature of 220 deg. in Weir's heater, by steam taken from the L.P. casing, at a pressure of 10 or 11 lb. Either or both of the main engine feed-pumps were used to raise the water from the hot well to the heater, whence it was delivered to the boilers by Weir's pumps, each of which used to be worked alternately with the other. The evaporator possessed a capacity of 20 tons fresh water per day, steam being taken from the I.P. casing to the coils, and drained thence into the hot well, the vapor being generated at about 15 lb., and led to the L.P. casing in the usual manner. As a rule, the evaporator was in use only about nine hours per day, or in other words, supposing it to work at its maximum rate, the total amount of extra feed was about 7 1-2 tons per day, which, however, must be considered as over the actual quantity, glands, joints, etc., being in excellent condition; and, not only that, but before the scale which forms on the coils of Weir's evaporator cracks off it often attains a considerable thickness, even when due attention is paid to frequent blowing out and running up with cold water.

Compared with Morison's evaporator, in which live steam is used, there is a loss in this system; for, by passing the vapor into the heater in the former, fresh water is obtained at a cost, theoretically, of the heat lost through brining; while, in Weir's system, there is first the loss of the latent heat of the vapor generated, and second, the loss due to brining or blowing off.

The following figures may be of interest as comparing the cost of fresh water in the two cases:

Boiler Press Absolute	= 175 lb.	temperature	370.4 deg.
I.P. Casing " "	= 70 lb.	"	302.5 "
L.P. " " "	= 25 lb.	"	240 "
Evaporator Shell "	= 30 lb.	"	250 "
Hot well, without Evaporator		"	100 "
Discharge Water, for Evaporator Feed		"	110 "

Density of evaporator 4-32, *i.e.*, quantity blown off = 1-3 evaporation.

The total heat of steam at 30 lb. absolute above temperature of water of 110 deg. is = 1,080 thermal units per lb., the heat lost by blowing down = 1-3 (250-100) thermal units per lb. evaporated; ∴ The total heat required to evaporate 1 lb. fresh water = 1,130 thermal units.

Suppose steam in the coils at 70 lb. all condensed to water of 292 deg., then the heat given up per lb. is = 912 thermal units, or, 1 lb. of steam taken from I.P. casing at 70 lbs., returns $\frac{912}{1130}$ = 8 lb. of steam to L.P. casing.

Let total I.H.P. of the engine = P
" " Extra feed = x lbs. per hour.
" " Water per I.H.P. = 13.5 lb.

Then since the consumption is = 1.23 lb. per I.H.P. per hour, 1 lb. coal produces $\frac{13.5}{1.23}$ = 11 lb. of steam at 370.4 deg. from water of 220 deg.

The quantity of steam required to make x lbs. water is = $\frac{x}{.8}$ = 1.25x lbs.

The quantity of steam returned to L.P. casing = x lbs.

Total steam passing H.P. Cylinder = 13.5 P lb. per hour, I.P. Cylinder = 13.5 P — 1.25x, and L.P. Cylinder = 13.5 P — .25x.

Assuming power equally divided among the three engines, as it was in this case, I.H.P. of H.P. Engine $= \frac{1}{3}P$; I.P. $= \frac{1}{3}\left(P - \frac{1.25x}{13.5}\right)$; L.P. $= \frac{1}{3}\left(P - \frac{.25x}{13.5}\right)$

Total I.H.P. $= P - \frac{1.5x}{3 \times 13.5} = P - .037x$;

∴ The loss of I.H.P. is = .037x, equivalent to .037 × 1.23 lb. of coal (= .046) per lb. of water evaporated.

Now the heat returned to the hot well by drain water from the coils is = 302 — 100 = 202 thermal units per lb. condensed steam. Also 1 lb. of coal evaporates 11 lbs. of steam at 370.4 deg. from water of 220 deg., or thermal value of coal = 11 × (1,195—188) = 11,077 thermal units; ∴ Heat returned to hot well per lb. of steam condensed in the coils = $\frac{192}{11,077}$ = .0182 lb. of coal; ∴ saving per lb. of fresh water evaporated = .0182 × 1.25 = .0227, and ∴ nett cost of 1 lb. of fresh water = .046 — .0227 = .0233 lb. of coal, or 1 lb. of coal will produce 41 lb. of water.

With Morison's evaporator, all the heat, except that lost by brining, being returned amongst the feed-water, the figures are much more simple.

Evaporator shell pressure 20 lb. absolute gives a temperature of 227 deg., and the evaporator feed 110 deg., while the density of the evaporator is $\frac{3}{32}$; the total heat required per lb. of fresh water evaporated

$$= \frac{227 - 110}{2} = 58.5 \text{ thermal units.}$$

Taking the value of a lb. of coal as 9 lb. of water, in this case evaporated at 370.4 deg. (the usual working pressure being 160 lb.), from feed-water of 180 deg.:— 1 lb. of coal = 9 × (1,195—[180—32]) = 9.423 units;

∴ lbs. of water per lb. of coal = $\frac{9.423}{58.5}$ = 161, or nearly four times the production of A's. The coal required to generate the supply of fresh water in A at the above figures works out at very approximately 1 per cent of the consumption, and in B at .03 per cent.

But if Weir's heater be taken into account, as is only fair, the advantage undoubtedly lies with it, as the following will show:

Steam is taken from the L.P. casing at a temperature of 240 deg., and mixing with the water in the heater at a temperature of 110 deg., raises it to 220 deg.

Let x lb. steam be taken per lb. of water heated, then 1.155x + (110—32) = (x + 1) (220—32) 967x = 110 lb., and x = .114 lb.

Let y denote the fraction of 1 lb. of steam left in casing per original lb., then .114 y denotes the fraction required in the heater 1.114 y = 1 lb., y = .89 lb.

Supposing, as before, power is equally distributed, then of one H.P. throughout the whole engine, only .89 × $\frac{1}{3}$ = .3 is developed in the L.P. engine; ∴ only .66 + .3 = .966 I.H.P. remains, or with heater in use I.H.P. is only 96.6 per cent of what it is without the heater.

The fuel required is = 100 × $\frac{1,017}{1,117}$ = 91 per cent;

∴ " " to get original H.P. = 91 × $\frac{100}{96.6}$

= 94.2 per cent, and ∴ the saving of fuel = 5.8 per cent, and cost of fresh water = 1 per cent, thus giving a nett saving of fuel = 4.8 per cent, when using evaporator and heater, as against a nett cost of .03 per cent of the fuel when evaporating 10 tons per day in Morison's evaporator and heater as in B.

The above figures are only given as relating to the different cases under present consideration, and the greater part of the data is taken from actual working.

Another point that might be noticed is that Weir's pumps, though as near perfection as can be had, are by no means remarkably economical with regard to steam, although they may in a manner be compounded by turning the exhaust into the L.P. casing, as is usually done; still taking into account the diminished friction at the main feed pump glands, and the high temperature at which it is possible to deliver the feed, the balance may be pretty even; it is unquestionable that with Weir's pumps there is an immense saving in the tear and wear of valves and pipes.

In both steamships A and B, Auld's reducing valves were used, but while in the former all the auxiliaries with the exception of Weir's pumps were arranged to work either with reduced or high pressure steam, the first-mentioned was invariably used (80 lb.); in the latter both fan and steering engines worked at full boiler pressure, a great source of waste, for besides the difficulty of keeping glands, valves and pistons tight, there is bound to be excessive condensation in the pipes. On the other hand, by reducing the pressure of the steam, it is practically superheated, and not only so, but a greater volume being required to perform the same amount of work, the flow through the pipes is

much more rapid, so that the temperature of the pipe is thereby maintained more uniform.

In A.—The fan and electric engines were duplicate, and the arrangement was such as to permit of the belts being changed, and thus each engine could be used to drive either the fan or dynamo. The belts used were Tullis' patent hinged chain belts, which lasted well, and drove without much slip, considering that the slack side was below. Sheet iron troughs were fitted in the eccentric pits and filled with fresh water; this soon worked up into a fine lather with the oil, and besides the drip from the valve spindle glands, little water was used in keeping them full. The eccentric sheaves had a working face 4 in. wide, both straps and sheaves being of cast iron, and the upper halves of the go-ahead straps filled with white metal. The result obtained was very satisfactory, wear being slight and faces like silver. That these engines were otherwise good-running jobs will be appreciated when I say that after running 15,000 miles all the slack in the crank-pins was taken up by removing a brown paper liner, or = 1-4 in. on the nuts. Salt water as a lubricant was carefully avoided throughout the engine-room and tunnel, although the tunnel bearings ran so warm that they could hardly be touched, and the thrust temperature was somewhere in the vicinity of 200 deg. Fahr.

The shafting was turned bright throughout, and the absence of water permitted of its being kept so, and also saved a lot of labor and material in keeping the tunnel plates and floor free from rust.

The cylinder and casing drains were each led into the condenser by a separate pipe and valve, and Weir's pumps being arranged to draw from the condenser, all the steam used in the process of warming up was returned to the boilers, so that instead of the level falling, it really rose at the expense of the donkey boiler, as all exhausts were turned into the condenser.

Pipe-flanges were of extra strength, so that such a thing as a blowing joint was of rare occurrence, thus obviating a frequent cause of waste. Clearance spaces in the cylinders were small, and before leaving the shop the slide-valves were carefully set and expansion blocks graduated in inches of the stroke corresponding to the different cut-offs, the ranges being in the H.P. from 23 3-4 ins. to 33 1-2 in., I.P. 22 1-4 in. to 32 in., and L. P. 21 in. to 29 1-2 in. That the high pressure slide-valve was perfectly tight after several months running, was evident from the fact that the author, while working in or out of port, was never in the habit of shutting the stop-valve, even when stopped for 15 or 20 minutes, but used the throttle alone—which was one of the type whose position when closed is at right angles to the center line of the pipe—without any perceptible increase in the pressure of the I.P. casing, all drains being shut.

Reconstruction of the U. S. S. Hartford.

Admiral Farragut's old flagship, the *Hartford*, has been placed in commission at the Mare Island Navy Yard, California. Lightly sparred, but heavy of hull and armament, the proud victor of many hard fought naval battles swings at the buoy in the stream off the Ordnance Building ready for her trip around the Horn, which is to take place at a date soon to be fixed by the Navy Department. Ten years ago the *Hartford* steamed into San Francisco bay after a voyage from the Asiatic Station, her flag was hauled down and a Board of Survey reported that the cost of repairs would exceed the 20 per cent of original cost permitted by law. The ship was therefore condemned and ordered sold.

To-day the famous fighter is one of the most unique and comfortable ships in the new Navy. She is indeed a wooden craft, but in all other respects she is strictly up-to-date, with new machinery, a fine battery of 5-in. rapid fire guns, electric plant, ice plant; in short, she possesses an equipment such as would be carried on a more formidable vessel, and at the same time she is a floating home for officers and crew. The masts are short and carry but a few yards. Her crew is made up of landsmen who have yet to be trained in the art of sailing, and there is just enough left of the original spars to give the men a chance to spread a little canvas.

In working the ship over the original timbers were preserved as far as was practicable, great care being exercised in keeping anything but the hardest wood out of the hull. Most of the original wood is to be found in the keel and about the magazines. A large portion of the tough old deck-planks was taken out of the ship altogether and made into souvenir canes, which were eagerly sought by navy people.

To the people of Vallejo, just across the Straits from the Navy Yard, is due the credit of securing favorable action in the matter of an appropriation for the reconstruction of the *Hartford*. The Board of Trade of that city four years ago took up the fight and succeeded in securing the money needed with the understanding that the funds be used as follows: $276,000 for restoring the hull, $150,000 for boilers and engines, $150,000 for armament.

The Navy Department ordered the engines made at the New York Navy Yard, but this order was afterward rescinded, and the Mare Island Yard did the work. Construction was commenced as soon as authority was wired, under the supervision of Chief Engineer George F. Kutz, who was retired before the work was completed. Captain Joseph Trilley, lately retired, took up the work where Engineer Kutz had left off and carried it through to the finish.

Regarding the *Hartford* engines, they are of the horizontal compound back-acting type; high pressure cylinder 35 in. dia. and low pressure 68 in. dia. and 48 in. stroke. Two thousand indicated horse-power is expected when running 75 revolutions per minute. The boilers are four single Scotch type, 11 ft. 1 1-2 in. outside dia. and 10 ft. long. They are constructed for a working pressure of 110 lbs. to the sq. in. The fire-rooms are fore and aft, with two boilers in each. The total heating surface is 6,340 sq. ft. There are two forced draft blowers, one main and one auxiliary feed pump and one fire and bilge pump. There is also a steam steering gear.

The ship is still on her original lines. She was built at Boston in 1858 and in dimensions is 225 ft. long over all, 44 ft. beam, 18 ft. 6 in. draft, and 2,790 tons displacement. In the place of the old-time 9-in. guns the ship now has fifteen 5-in. rapid fire guns, four 6-pounders, one 3-pounder rapid fire gun, and two Colt rifles. She will have 450 recruits on board.

U. S. S. HARTFORD AS SHE APPEARED IN HER ORIGINAL RIG BEFORE RECONSTRUCTION.

U. S. TRAINING SHIP HARTFORD, RECONSTRUCTED AND RE-ENGINED AT MARE ISLAND NAVY YARD, CALIFORNIA.

REVIEW OF PAST PROGRESS IN STEAM NAVIGATION AND FORECAST OF FUTURE DEVELOPMENT.*—I.

BY SIR WILLIAM WHITE, CONSTRUCTOR-IN-CHIEF, R. N.

In this address it is proposed to review briefly the characteristic features of the progress made in steam navigation; to glance at the principal causes of advance in the speeds of steamships and in the lengths of the voyages on which such vessels can be successfully employed; and to indicate how the experience and achievement of the last sixty years bear upon the prospects of further advance.

On this occasion no attempt will be made either to summarize or appraise the work that has been done. It must suffice to mention the names of three men to whom naval architects are deeply indebted, and whose labors are ended—Scott Russell, Rankine, and William Froude. Each of them did good work, but to Froude we owe the device and application of the method of model experiment with ships and propellers by means of which the design of vessels of novel types and unprecedented speeds can now be undertaken with greater confidence than heretofore.

As speeds increase, each succeeding step in the ascending scale becomes more difficult, and the rate of increase in the power to be developed rapidly augments. Looking back on what has been achieved, it is impossible to overrate the courage and skill displayed by the pioneers of steam navigation, who had at first to face the unknown, and always to depend almost entirely on experience gained with actual ships, when they undertook the production of swifter vessels. Their successors of the present day have equal need to make a thorough study of the performances of steamships, both in smooth water and at sea. In many ways they have to face greater difficulties than their predecessors, as ships increase in size and speed. On the other hand, they have the accumulated experience of sixty years to draw upon, the benefit of improved methods of trials of steamships, the advantage of scientific procedure in the record and analysis of such trials, and the assistance of model experiments.

Steamship design to be successful must always be based on experiment and experience as well as on scientific principles and processes. It involves problems of endless variety and great complexity. The services to be performed by steamships differ in character, and demand the production of many distinct types of ships and propelling apparatus. In all these types, however, there is one common requirement—the attainment of a specified speed. And in all types there has been a continuous demand for higher speed.

Stated broadly, the task set before the naval architect in the design of any steamship is to fulfil certain conditions of speed in a ship which shall not merely carry fuel sufficient to traverse a specified distance at that speed, but which shall carry a specified load on a limited draught of water. Speed, load, power, and fuel supply, are all related, and the two last have to be determined in each case. In some instances, other limiting conditions are imposed, affecting length, breadth or depth. In all cases there are three separate efficiencies to be considered: those of the ship, as influenced by her form; of the propelling apparatus, including the generation of steam in the boilers and its utilization in the engines, and of the propellers. Besides these considerations the designer has to take account of the materials and structural arrangements which will best secure the association of lightness with strength in the hull of the vessel. He must select those types of engines and boilers best adapted for the service proposed. Here the choice must be influenced by the length of the voyage, as well as the exposure it may involve to storm and stress. Obviously the conditions to be fulfilled in an ocean-going passenger steamer of the highest speed, and in a cross-channel steamer designed to make short runs at high speed in comparatively sheltered waters, must be radically different. And so must be the conditions in a swift sea-going cruiser of large size and great coal endurance, from those best adapted for a torpedo boat or destroyer. There is, in fact, no general rule applicable to all classes of steamships; each must be considered and dealt with independently, in the light of the latest experience and improvements. For merchant ships there is always the commercial consideration: Will it pay? For warships there is the corresponding inquiry: Will the cost be justified by the power and efficiency of the proposed ship?

CHARACTERISTICS OF PROGRESS IN STEAM NAVIGATION.

Looking at the results so far attained, it may be said that progress in steam navigation has been marked by the following characteristics:

(1) Growth in dimensions and weights of ships, and large increase in engine power as speeds have been raised. (2) Improvements in marine engineering, accompanying increase of steam pressure. Economy of fuel and reduction in the weight of propelling apparatus in proportion to the power developed. (3) Improvements in the materials used in shipbuilding; better structural arrangements; relatively lighter hulls and larger carrying power. (4) Improvements in form, leading to diminished resistance and economy of power expended in propulsion. These general statements represent well-known facts—so familiar indeed that their full significance is often overlooked. It would be easy to multiply illustrations, but only a few representative cases will be taken.

TRANSATLANTIC PASSENGER STEAMERS.

The transatlantic service naturally comes first. It is a simple case, in that the distance to be covered has remained practically the same, and that for most of the swift passenger steamers cargo-carrying capacity is not a very important factor in the design. In 1840 the Cunard steamer *Britannia*, built of wood, propelled by paddle-wheels, maintained a sea speed of about 8 1-2 knots. Her steam pressure was 12 lb. per sq. in. She was 207 ft. long, about 2,000 tons in displacement, her engines developed about 750 horse power, and her coal consumption was about 40 tons per day, nearly 5 lb. of coal per indicated horse power per hour. She had a full spread of sail. In 1871 the White Star steamship *Oceanic*—first of that name—occupied a leading position. She was iron-built, propelled by a screw, and maintained a sea-speed of about 14 1-2 knots. The steam pressure was 65 lb. per sq. in., and the engines

*From a paper read before the British Association, Mechanical Science Section.

were on the compound principle. She was 420 ft. long, about 7,200 tons in displacement, her engines developed 3,000 horse power, and she burnt about 65 tons of coal per day, or about 2 lb. per indicated horse power per hour. She carried a considerable spread of sail. In 1889 the White Star steamer *Teutonic* appeared, propelled by twin screws, and practically with no sail power. She is steel-built, and maintains a sea speed of about 20 knots. The steam pressure is 180 lb. per sq. in., and the engines are on the triple expansion principle. She is about 565 ft. long, 16,000 tons in displacement, 17,000 horse power indicated, with a coal consumption of about 300 tons a day, or from 1.6 to 1.7 lb. per indicated horse power per hour. In 1894 the Cunard steamship *Campania* began her service with triple-expansion engines, twin screws, and no sail power. She is about 600 ft. long, 20,000 tons displacement, develops about 28,000 horse power at full speed of 22 knots, and burns about 500 tons of coal per day. The new *Oceanic* of the White Star Line is just beginning her work. She is of still larger dimensions, being 685 ft. in length, and over 25,000 tons displacement. From the authoritative statements made it appears that she is not intended to exceed 22 knots in speed, and that the increase in size is to be largely utilized in additional carrying power. The latest German steamers for the transatlantic service are also notable. A speed of 22 1-2 knots has been maintained by the *Kaiser Wilhelm der Grosse*, which is 25 ft. longer than the *Campania*. Two still larger steamers are now building. The *Deutschland* is 660 ft. long, and 23,000 tons displacement; her engines are to be of 33,000 horse power, and it is estimated that she will average 23 knots. The other vessel is said to be 700 ft. long, and her engines are to develop 36,000 horse power, giving an estimated speed of 23 1-2 knots. All these vessels have steel hulls and twin screws. It will be noted that to gain about 3 knots an hour nearly 50 per cent will have been added to the displacement of the *Teutonic*, the engine power and coal consumption will be doubled, and the cost increased proportionately.

Sixty years of continuous effort and strenuous competition on this great "ocean ferry" may be summarized in the following statement: Speed has been increased from 8 1-2 to 22 1-2 knots; the time on the voyage has been reduced to about 38 per cent of what it was in 1840. Ships have been more than trebled in length, about doubled in breadth, and increased tenfold in displacement. The engine power has been made forty times as great. The ratio of horse power to the weight driven has been increased fourfold. The rate of coal consumption—measured per horse power per hour—is now only about one-third what it was in 1840. To drive 2,000 tons weight across the Atlantic at a speed of 8 1-2 knots per hour, about 550 tons of coal were then burnt; now, to drive 20,000 tons across at 22 knots, about 3,000 tons of coal are burnt. With the low pressure of steam and heavy slow-moving paddle-engines of 1840, each ton weight of machinery, boilers, etc., produced only about 2 horse power. With modern twin-screw engines and high steam pressure, each ton weight of propelling apparatus produces from 6 horse power to 7 horse power. Had the old rate of coal consumption continued, instead of 3,000 tons of coal, 9,000 tons would have been required for a voyage at 22 knots. Had the engines been proportionately as heavy as those in use sixty years ago they would have weighed about 14,000 tons. In other words, machinery, boilers, and coals would have exceeded in weight the total weight of the *Campania* as she floats to-day. There could not be a more striking illustration than this of the close relation between improvements in marine engineering and the development of steam navigation at high speeds.

Equally true is it that this development could not have been accomplished but for the use of improved materials and structural arrangements. Wood, as the principal material for the hulls of high-powered swift steamers, imposed limits upon dimensions, proportions and powers, which would have been a bar to progress. The use of iron first and since of steel removed those limits. The percentage of the total displacement devoted to hull in a modern Atlantic liner of the largest size is not much, if at all, greater than was the corresponding percentage in the wood-built *Britannia* of 1840, of one-third the length and one-tenth the total weight. Nor must it be overlooked that with increase in dimensions have come considerable improvements in form favoring economy in propulsion. This is distinct from the economy resulting from increase in size, which Brunel appreciated thoroughly half a century ago when he designed the *Great Britain* and the *Great Eastern*. The importance of a due relation between the lengths of the "entrance and run" of steamships and their intended maximum speeds, and the advantages of greater length and fineness of form as speeds are increased, were strongly insisted upon by Scott Russell and Froude. Naval architects, as a matter of course, now act upon the principle, so far as other conditions permit. For it must never be forgotten that economy of propulsion is only one of many desiderata which must be kept in view in steamship design. Structural weight and strength, seaworthiness, and stability, all claim attention, and may necessitate modifications in dimensions and form which do not favor the maximum economy of propulsion. Increase in length and weight have largely assisted the marvelous regularity of service now attained on the longest passages by swift steamships. Even the largest vessels at times have to yield to the forces of nature displayed in wind and sea. But these conditions are more rarely reached in the longer and heavier ships.

SWIFT PASSENGER STEAMERS FOR LONG VOYAGES.

Changes similar to those described for the transatlantic service have been in progress on all the great lines of ocean traffic. In many instances increase in size has been due not only to increase in speed, but to enlarged carrying power, and the extension of the lengths of voyages. No distance is now found too great for the successful working of steamships, and the sailing fleet is rapidly diminishing in importance. So far as long-distance steaming is concerned, the most potent factor has undoubtedly been the marvellous economy of fuel that has resulted from higher steam pressures and greater expansion. In all cases, however, advances have been made possible not merely by economy of fuel, but by improvements in form, struc-

ture and propelling apparatus, and by increased dimensions. Did time permit, this might be illustrated by many interesting facts drawn from the records of the great steamship companies which perform the services to the Far East, Australia, South America, and the Pacific. As this is not possible, I must be content with the statement of a few facts regarding the development of the fleet of the Peninsular and Oriental Company:

The paddle steamer *William Fawcett*, of 1829, was about 75 ft. long, 200 tons displacement, of 60 nominal horse power—probably about 120 indicated horse power —and in favorable weather steamed at a speed of 8 knots. Her hull was of wood, and, like all the steamers of that date, she had considerable sail power. In 1853 the *Himalaya*, iron-built screw steamer of this line, was described as "of larger dimensions than any then afloat, and of extraordinary speed." She was about 340 ft. long, over 4,000 tons load displacement, 2,000 indicated horse power on trial, with an average sea speed of about 12 knots. The steam pressure was 14 lb. per sq. in., and the daily coal consumption about 70 tons. This vessel was transferred to the Royal Navy, and did good service as a troopship for forty years. In 1893 another *Himalaya* was added to the company's fleet. She was steel-built, nearly 470 ft. long and 12,000 tons load displacement, with over 8,000 indicated horse power and a capability to sustain 17 to 18 knots at sea, on a daily consumption of about 140 tons of coal. The steam pressure is 160 lb. per sq. in., and the engines are of the triple-expansion type. Comparing the two *Himalayas*, it will be seen that in forty years the length has been increased about 40 per cent, displacement trebled, horse power quadrupled, and speed increased 50 per cent. The proportion of horse power to displacement has only been increased as three to four, enlarged dimensions having secured relative economy in propulsion. The rate of coal consumption has been probably reduced to about one-third of that in the earlier ship. The latest steamers of the line are of still larger dimensions, being 500 ft. long and of proportionately greater displacement. It is stated that the *Himalaya* of 1853 cost $660,000 complete for sea; the corresponding outlay on her successors is not published, but it is probably twice as great.

On the service to the Cape of Good Hope similar developments have taken place. Forty years ago vessels less than 200 ft. long and about 7 knots performed the service, whereas the latest additions to the fleets exceed 500 ft. in length, and can, if required, be driven at 17 to 18 knots, ranking in size and power next to the great transatlantic liners. Commercial considerations necessarily regulate what is undertaken in the construction of merchant steamers, including the swift vessels employed in the conveyance of passengers and mails. The investment of $3,000,000 to $3,500,000 in a single vessel like a great transatlantic liner is obviously a serious matter for private owners; and even the investment of half that amount in a steamer of less dimensions and speed is not to be lightly undertaken.

It is a significant fact that, whereas fifteen years ago nearly all the largest and swiftest ocean steamers were British built and owned, at the present time there is serious competition in this class by German, American and French companies. It is alleged that this change has resulted from the relatively large subsidies paid by foreign governments to the owners of swift steamers; and that British owners, being handicapped in this way, cannot continue the competition in size and speed on equal terms unless similarly assisted. This is not the place to enter into any discussion of such matters. But they obviously involve greater considerations than the profit of ship-owners, and have a bearing on the naval defence of the Empire. In 1887 the Government recognized this fact, and made arrangements for the subvention and armament of a number of the best mercantile steamships for use as auxiliary cruisers. Since then other nations have adopted the policy, and given such encouragement to their shipowners that the numbers of swift steamers suitable for employment as cruisers have been largely increased. Not long since the First Lord of the Admiralty announced to Parliament that the whole subject was again under consideration.

Cargo steamers, no less than passenger steamers, have been affected by the improvements mentioned. Remarkable developments have occurred recently, not merely in the purely cargo carrier, but in the construction of vessels of large size and good speed, carrying very great weights of cargo and considerable numbers of passengers. The much-decried "ocean tramp" of the present day exceeds in speed the passenger and mail steamer of fifty years ago. Within ten years vessels in which cargo-carrying is the chief element of commercial success have been increased in length from 300 ft. or 400 ft. to 500 ft. or 600 ft.; in gross register tonnage from 5,000 to over 13,000 tons, and in speed from 10 or 12 knots to 15 or 16 knots. Vessels are now building for the Atlantic service which can carry 12,000 to 13,000 tons deadweight, in addition to passengers, while possessing a sea-speed as high as that of the swiftest mail steamers afloat in 1880. Other vessels of large carrying power and good speed are running on much longer voyages, such as to the Cape and Australia. In order to work these ships successfully very complete organization is necessary for the collection, embarkation, and discharge of cargo. The enterprise and skill of shipowners have proved equal to this new departure, as they have in all other developments of steamships.

How much further progress will be made in the sizes and speeds of these mixed cargo and passenger steamers cannot be foreseen. The limits will be fixed by commercial considerations, and not by the capability of the shipbuilder. In passing it may be noted that while the lengths and breadths of steamships have been greatly increased, there has been but a moderate increase in draft. Draft of water is, of course, practically determined by the depths available in the ports and docks frequented, or in the Suez Canal for vessels trading to the East. From the naval architect's point of view increase in draught is most desirable as favoring increase of carrying power and economy of propulsion. This fact has been strongly represented by shipowners and ship designers, and not without result. The responsible authorities of many of the principal ports and of the Suez Canal have taken action towards giving greater depth. Other changes have become necessary on the part of dock and port authorities in consequence of the progress made in shipbuilding.

Docks and dock entrances have had to be increased in size, more powerful lifting appliances provided, and large expenditure incurred. There is no escape from these changes if the trade of a port is to be maintained. The chief lesson to be learned from past experience is that when works of this character are planned it is wise to provide a large margin beyond the requirements of existing ships.

CROSS-CHANNEL STEAMERS.

The conditions to be fulfilled in vessels designed to steam at high speed for limited periods obviously differ essentially from those holding good in ocean-going steamers. None the less interest attaches, however, to cross-channel steamers, and in no class has more notable progress been made. It is much to be desired that, at this meeting, some competent authority should have presented to the association an epitome of the history of the steam-packet service between Dover and the Continent. I cannot attempt it. So far as I am informed, the first steamer was placed on this route in 1821, was of 90 tons burden, 30 horse power nominal, and maintained a speed of 7 to 8 knots. She was built by Denny, of Dumbarton, engined by Robert Napier, and named the *Rob Roy*. It is interesting to note that the lineal successors of the builder of this pioneer vessel have produced some of the most recent and swiftest additions to the cross-channel service. In 1861-2 a notable advance was made by the building of vessels which were then remarkable for structure and speed, although small and slow when compared with vessels now running. Their designers realized that lightness of hull was of supreme importance, and with great trouble and expense obtained steel of suitable quality. The machinery was of special design, and relatively light for the power developed. A small weight of coal and cargo had to be carried, and the draft of water was kept to about 7 ft. Under then existing conditions it was a veritable triumph to attain speeds of 15 to 16 knots in vessels only 190 ft. long, less than 25 ft. broad, and under 350 tons in displacement. To raise the trial speed to 21 or 22 knots in later vessels, whose design includes the improvements of a quarter of a century, it has been found necessary to adopt lengths exceeding 320 ft., and breadths of about 35 ft., with engines developing 4,500 to 6,000 indicated horse power, and with very great increase in coal consumption and cost.

Another interesting contrast is to be found in the comparison of the mail steamers running between Holyhead and Kingstown in 1860, and at the present time. The *Leinster* of 1860 was 328 ft. long, 35 ft. broad, and rather less than 13 ft. draft. Her trial displacement was under 2,000 tons, and with 4,750 horse power she made 17 3-4 knots. She had a steam pressure of 25 lb. per sq. in., and was propelled by paddle-wheels driven by slow-moving engines of long stroke. Her successor of 1896 is about 30 ft. greater length, 6 1-2 ft. greater breadth, and about 10 per cent greater displacement. The steam pressure is 160 lb. per sq. in. Forced draft is used in the stokehold. Twin screws are adopted, driven by quick-running vertical engines of the triple-expansion type. Very great economy of coal consumption is thus secured, as compared with the earlier vessel, and much lighter propelling apparatus in proportion to the power, which is from 8,000 horse power to 9,000 horse power at the full speed of 23 knots. The hull is built of steel, and is proportionately lighter. This is a typical case, and illustrates the effect of improvements in shipbuilding and engineering in thirty-five years. The later ship probably requires to carry no greater load of coal than, if so great as, her predecessor, although her engine power is nearly double. The weight devoted to propelling machinery and boilers is probably not so great. Thanks to the use of steel instead of iron, and to improved structural arrangements, the weight of hull is reduced in comparison with dimension, and a longer ship is produced better adapted to the higher speed. Messrs. Laird, of Birkenhead, who built three of the *Leinster* class forty years ago, and have built all the new vessels, are to be congratulated on their complete success. Between such vessels designed for short runs at high speed, and requiring therefore to carry little coal, while the load carried exclusive of coal is trifling, and an ocean-going steamer of the same average speed designed to make passages of 3,000 miles, there can obviously be little in common. But equal technical skill is required to secure the efficient performance of both services. In the cross-channel vessel, running from port to port and under constant observation, conditions of working in engine and boiler-rooms, as well as relative lightness in scantlings of hull, can be accepted which would be impossible of application in the sea-going ship. These circumstances, in association with the small load carried, explain the apparent gain in speed of the smaller vessel in relation to her dimensions.

INCREASE IN SIZE AND SPEED OF WARSHIPS.

Turning from sea-going ships of the mercantile marine to warships, one finds equally notable facts in regard to increase in speed, associated with enlargement in dimensions and advance in propelling apparatus, materials of construction, structural arrangements and form. Up to 1860 a measured-mile speed of 12 to 13 knots was considered sufficient for battleships and the largest classes of cruisers. All these vessels possessed good sail power, and used it freely as an auxiliary to steam or as an alternative when cruising or making passages. When armored battleships were built (1859) the speeds on measured-mile trials were raised to 14 or 14 1-2 knots, and so remained for about twenty years. Since 1880 the speeds of battleships have been gradually increased, and in the latest types the measured-mile speed required is 19 knots. Up to 1870 the corresponding speeds in cruisers ranged from 15 to 16 knots. Ten years later the maximum speeds were 18 to 18 1-2 knots in a few vessels. Since then trial speeds of 20 to 23 knots have been attained, or are contemplated.

There is, of course, a radical distinction between these measured-mile performances of warships and the average sea speeds of merchant steamers above described. But for purposes of comparison between warships of different dates measured-mile trials may fairly be taken as the standard. For long-distance steaming the power developed would necessarily be much below that obtained for short periods, and with everything at its best. This is frankly recognized by all who are conversant with warship design, and fully allowed for in estimates of sea speeds. On the other hand it is possible to

point to sea trials made with recent types where relatively high speeds have been maintained for long periods. For example, the battleship *Royal Sovereign* has maintained an average speed of 15 knots from Plymouth to Gibraltar, and the *Renown* has maintained an equal speed from Bermuda to Spithead. As instances of good steaming by cruisers, reference may be made to 60-hour trials with the *Terrible*, when she averaged over 20 knots, and to the run home from Gibraltar to the Nore by the *Diadem*, when she exceeded 19 knots. Vessels of the *Pelorus* class of only 2,100 tons displacement have made long runs at sea averaging over 17 knots. Results such as these represent a substantial advance in speed of Her Majesty's ships in recent years. Similar progress has been made in foreign warships built abroad as well as in this country.

It is not proposed to give any facts for these vessels, or to compare them with results obtained by similar classes of ships in the royal navy. Apart from full knowledge of the conditions under which speed trials are made, a mere statement of speeds attained is of no service. One requires to be informed accurately respecting the duration of the trial, the manner in which engines and boilers are worked, the extent to which boilers are "forced," or the proportion of heating surface to power indicated, the care taken to eliminate the influence of tide or current, the mode in which the observations of speed are made, and other details, before any fair or exact comparison is possible between ships. For present purposes, therefore, it is preferable to confine the illustrations of increase in speed in warships to results obtained under Admiralty conditions, and which are fairly comparable.

A great increase in size has accompanied this increase in speed, but it has resulted from other changes in modern types, as well as from the rise in speed. Modern battleships are of 13,000 to 15,000 tons, and modern cruisers of 10,000 to 14,000 tons, not merely because they are faster than their predecessors, but because they have greater powers of offence and defence, and possess greater coal endurance. Only a detailed anaylsis, which cannot now be attempted, could show what is the actual influence of these several changes upon size and cost, and how greatly the improvements made in marine engineering and shipbuilding have tended to keep down the growth in dimensions consequent on increase in load carried, speed attained, and distance traversed. It will be noted also that large as are the dimensions of many classes of modern warships, they are all smaller in length and displacement than the largest mercantile steamers above described. There is no doubt a popular belief that the contrary is true, and that warships exceed merchant ships in tonnage. This arises from the fact that merchant ships are ordinarily described, not by their "displacement" tonnage, but by their "registered" tonnage, which is far less than their displacement. As a matter of fact, the largest battleships are only of about two-thirds the displacement of the largest passenger steamers, and from 200 ft. to 300 ft. shorter. The largest cruisers are from 100 ft. to 200 ft. shorter than the largest passenger steamers, and about 60 per cent of their displacement. In breadth the warships exceed the largest merchant steamers by from 5 ft. to 10 ft. This difference in form and proportions is the result of radical differences in the vertical distribution of the weights carried, and is essential to the proper stability of the warships. Here we find an illustration of the general principle underlying all ship designing. In selecting the forms and proportions of a new ship considerations of economical propulsion cannot stand alone. They must be associated with other considerations, such as stability, protection and manœuvring power, and in the final result economy of propulsion may have to be sacrificed to some extent in order to secure other essential qualities.

Society of Naval Architects and Marine Engineers.

The seventh general meeting of the Society of Naval Architects and Marine Engineers will take place in New York city, at 10:00 A. M., Thursday, November 16, 1899. Through the courtesy of the President and Managers of the American Society of Mechanical Engineers, the meetings will be held in the Auditorium of 12 West Thirty-first street, the sessions continuing through Thursday and Friday, November 16 and 17. There will be a banquet at Delmonico's at 7 P. M., Friday, November 17. The Council will meet in the regular place on Wednesday, November 15, at 3 o'clock in the afternoon. The list of papers to be read at the meeting is as follows:

THURSDAY, NOVEMBER 16, 1899.

1. Coaling Vessels at Sea.
   By Spencer Miller, Esq., Associate.
2. Causes for the Adoption of Water-Tube Boilers in the U. S. Navy.
   By Engineer-in-Chief George W. Melville, U. S. N., Vice-President.
3. Suggestions as to Improved Appliances for Launching Ship's Boats.
   By John Hyslop, Esq.
4. The Electric Plants of the Battleships *Kearsarge* and *Kentucky*.
   By Naval Constructor J. J. Woodward, U. S. N., Member.
5. The Increasing Complications in Warships, and How Simpler Arrangements Might be Adopted.
   By George W. Dickie, Esq., Member of Council.
6. Beam Formulæ Applied to a Vertically Stiffened Bulkhead, with Some Results.
   By H. F. Norton, Esq., Member.
7. Notes on Sheathing the U. S. S. *Chesapeake*.
   By Naval Constructor Lloyd Bankson, U. S. N., Member.

FRIDAY, NOVEMBER 17, 1899.

8. System of Work in a Great Lake Shipyard.
   By W. I. Babcock, Esq., Member.
9. Overhead Cranes, Staging and Riveter Carrying Appliances in the Shipyard.
   By James Dickie, Esq., Member.
10. Designs for the Denver Class Sheathed Protected Cruisers.
    By Chief Constructor Philip Hichborn, U. S. N., Vice-President.
11. Novelties in Ship Fittings.
    By Assistant Naval Constructor R. M. Watt, U. S. N., Member.
12. Progressive Speed Trials of the U. S. S. *Manning*.
    By Prof. C. H. Peabody, Member of Council.
13. Tactical Considerations Involved in Torpedo Boat Design.
    By Lieut. A. P. Niblack, U. S. N., Associate.
14. On the Action of the Rudder, with Special Reference to the Motion of the Ship While the Helm is Being Put over.
    By Prof. William F. Durand, Member of Council.

It will be recalled that at the last meeting a resolution was adopted inviting papers on the subject of life-saving at sea, and from the papers submitted a selection of two was to be made for reading and discussion.

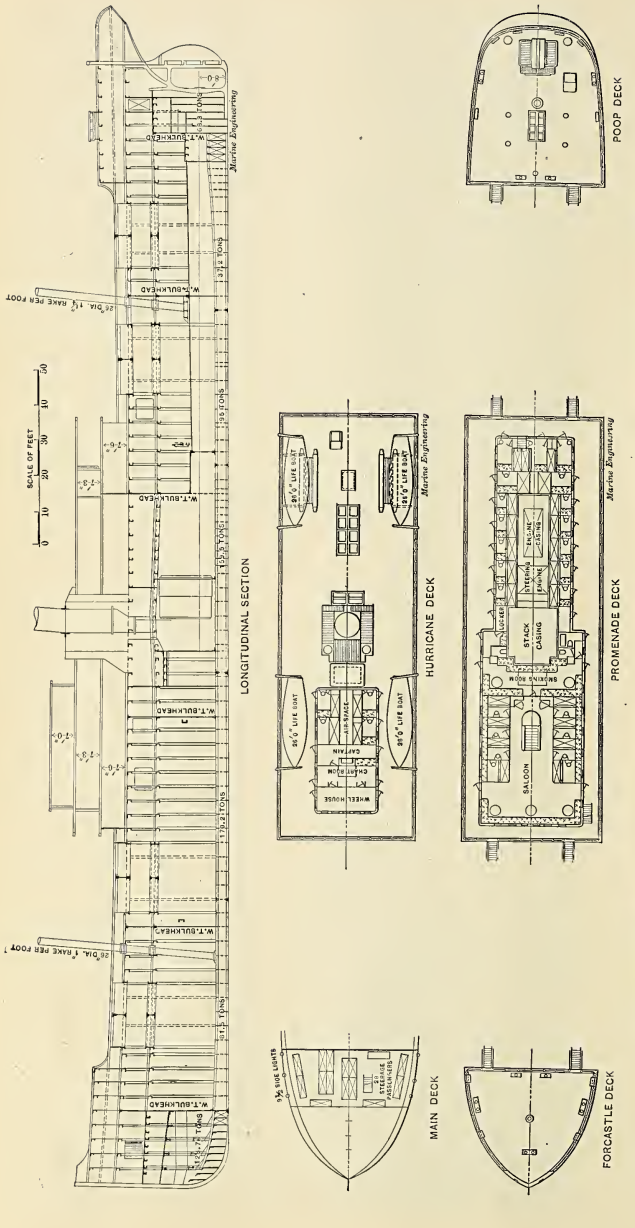
STEAMSHIP PONCE FOR NEW YORK & PORTO RICO S. S. CO., BUILT AND ENGINED BY HARLAN & HOLLINGSWORTH, WILMINGTON, DEL.

STEAMSHIP PONCE FOR REGULAR SERVICE BETWEEN NEW YORK AND PORTO RICO.

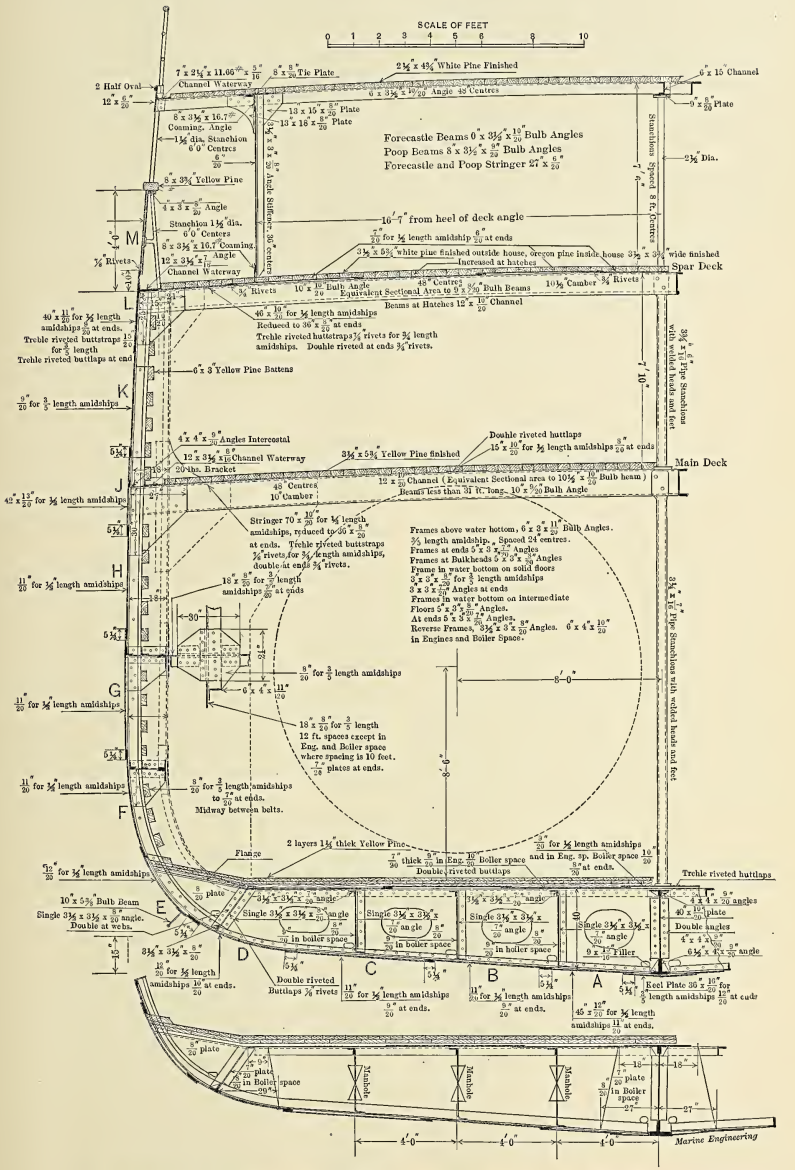
The steamship *Ponce*, recently completed by the Harlan & Hollingsworth Co., of Wilmington, Del., for the New York & Porto Rico S. S. Co., of New York, and which was much in evidence in New York harbor at the time of the Dewey celebration and the yacht races, and on which the Marconi system of wireless telegraphy was first introduced in this country, is one of the large new freight and passenger steamers which have been built as a result of the Spanish-American war. She is to form one of the connecting links with the new possessions in the Caribbean Sea. By those who have examined her, she is conceded to be superior to any steamship of her size, recently turned out here, in her freight and passenger accommodations. The *Ponce* is designed to carry the maximum amount of freight and passengers on a small coal capacity and is of the following dimensions:

Length over all	335 ft. 0 in.
Length between perpendiculars	317 ft. 0 in.
Length on water line	322 ft. 0 in.
Beam, moulded	42 ft. 0 in.
Depth at center to main deck	19 ft. 10 in.
Depth to spar deck	27 ft. 8 in.
Depth at side to spar deck	26 ft. 9 1-2 in.
Depth to main deck at side, moulded	19 ft. 0 in.
Draft, loaded	19 ft. 0 in.
Gross tonnage	3,503 tons.
Net	2,819 tons.
Dead weight carrying capacity	3,250 tons.

The *Ponce* is of the spar deck type, with topgallant forecastle, bridge and poop decks. In the topgallant forecastle are accommodations for the firemen and sailors fitted with pipe berths, also bath room and toilet room, lamp room and carpenter shop. The midship house is of steel and in the forward end of this is lo-



PLANS OF THE NEW PASSENGER AND FREIGHT STEAMER PONCE, BUILT FOR REGULAR SERVICE BETWEEN NEW YORK AND PORTO RICO.


SCALE OF FEET
0 1 2 3 4 5 6 8 10
Forecastle Beams 6" x 3½" x 19/20" Bulb Angles
Poop Beams 8 x 3½ x 25/32" Bulb Angles
Forecastle and Poop Stringer 27" x 5/8"
10'-7" from heel of deck angle
Spar Deck
Main Deck
Stanchions Spaced 8 ft. Centres
2¾" Dia.
Channel Waterway
Coaming, Angle
Stanchion 1¾" dia.
6'0" Centres
Yellow Pine
Rivets
Bulb Angle
Equivalent Sectional Area to 9" x 7/20" Bulb Beams
Beams at Hatches 12" x 15/20" Channel
Frames above water bottom, 6" x 3" x 11/20" Bulb Angles.
3/5 length amidships, Spaced 24 centres.
Frames at ends 5" x 3" x 7/20" Angles
Frames at Bulkheads 5" x 3" x 5/20" Angles
Frame in water bottom on solid floors
3" x 3" x 5/20" for 3/5 length amidships
3" x 3" x 5/20" Angles at ends
Frames in water bottom on intermediate
Floors 5" x 3" x 7/20" Angles.
At ends 5" x 3" x 7/20" Angles, 8" Reverse Frames, 3½" x 3" x 5/20" Angles. 6" x 4" x 10/20" in Engines and Boiler Space.
Stringer 70" x 10/20" for ¼ length amidships, reduced to 30" x 5/20" at ends. Treble riveted buttstraps 7/8" rivets for 3/5 length amidships, double at ends ¾" rivets.
Double riveted buttlaps
Stanchions with welded heads and feet
Fiddley
2 layers 1¼" thick Yellow Pine
Treble riveted buttlaps
Double riveted Buttlaps 7/8 rivets
Keel Plate 36" x 10/20" for 5/8 length amidships 12/20 at ends
Single 3½" x 3½" x 5/20" angle
Double angles
Filler
Manhole
Marine Engineering

HALF MID-SECTION OF STEAMSHIP PONCE, BUILT BY HARLAN & HOLLINGSWORTH, WILMINGTON, DEL.

cated the dining room, handsomely paneled in quartered oak, with staterooms similarly finished opening out of it, and a very handsome staircase of oak leading to the upper saloon. The bath rooms and toilet rooms are of the newest style of plumbing, finished with tiling. Abaft the dining room are the mail rooms, the galleys and pantries, together with the officers' staterooms. The second class accommodations are in the poop deck house, together with separate galleys, refrigerators and dining room, and while finished plainly, are as comfortable as those of the first class.

Above the midship deck house of steel is the saloon deck house of wood, with smoking room paneled with white maple and staterooms handsomely finished. Above this is the pilot house, chart room and captain's quarters, handsomely finished in hardwood.

The *Ponce* has two electric light plants, with a capacity of about 250 lights (16 c.p.) and all fittings, such as steam heating apparatus, plumbing, are of the newest models.

The engines are triple-expansion with inverted cylinders, with high-pressure cylinder 24 in. dia., intermediate cylinder 38 in. dia. and low-pressure cylinder 42 in. dia., and a common stroke of 42 in. Two single ended Scotch boilers are fitted, each with shell 14 ft. dia. and 12 ft. long. There are six furnaces 48 in. dia., and the boilers are fitted with the Ellis & Eaves equipment for induced draft. A donkey boiler 8 ft. by 9 ft. 3 in. is also included, with all necessary auxiliaries.

The *Ponce* has two steel masts with two cargo booms on each mast, four extremely large hatches and four Williamson double cylinder winches for handling cargo. A Hyde steam capstan windlass is fitted forward and steam capstan aft. She has six watertight bulkheads and an equipment of four 26 ft. metallic life-boats, two 18 ft. metallic life rafts, and the necessary inspection outfits.

She is certainly a great improvement in appearance over the usual type of seagoing American steamer, with excessive shear, attenuated smoke pipe and unsightly, flimsy, tinder box deck houses. The *Ponce* has been built on a guarantee to make 12 knots on 19 ft. load draft on her first trip to Porto Rico. She was built under the supervision of John Haug, Lloyds inspector.

S.S. Ivernia.—The new Cunarder *Ivernia*, building on the East Coast of England, will be one of the largest vessels afloat, although she will not be a record breaker in the matter of speed. This vessel is designed for the Boston-Liverpool route of the company, and has been designed chiefly for the carriage of steerage passengers, freight and cattle, although accommodations for a small number of cabin passengers will be fitted. The dimensions of the new vessel are: Length over all, 600 ft.; beam, extreme, 64 ft. 6 in.; depth to upper deck, 41 ft. 6 in.; gross tonnage 13,900 tons. The vessel will have twin screws, driven by quadruple expansion engines, with cylinders 28 1-2 in., 41 in., 58 1-2 in., and 84 in. dia., and 54 in. stroke. She will have nine single-ended boilers, built to work at a pressure of 210 lbs., and will have a single stack. The vessel was christened by the Countess of Ravenswood. A sister ship, the *Saxonia*, now under construction at Clydebank, has been the subject of many wild rumors as regards size and speed.

CONSIDERATION OF THE STEAM YACHT FROM THE DESIGNER'S POINT OF VIEW.—II.

BY WILLIAM A. FAIRBURN.

Having now rapidly sketched each type of vessel and described representative vessels of each class, let us consider a number of principles involved in steam yacht design. In the design of full powered steam yachts many problems affecting the motive power have to be solved. In the first place we must decide on single or twin screw propulsion. For efficiency of propulsion there is very little difference, the single screw being slightly superior. The twin screw engines have usually the disadvantage of being somewhat heavier than the single screw engine, and they may possibly take up just as much or even more room fore and aft owing to the location of the condenser and auxiliaries aft of the main engines, instead of being placed on the side, as is usual in single screw vessels. This, of course, applies to narrow vessels, such as high speed steam yachts, and the fact of placing both engines as near the center line of the ship as possible has little effect in overcoming the difficulty. By the adoption of twin screws, however, the weight can be put lower in the vessel, as engines of short stroke are usually adopted. The machinery parts are smaller, and in case of accident the vessel has two lives, for in case of one engine breaking down there is still another, and if that remains in good condition one need have no anxiety about reaching port.

Yacht engineers to-day are strongly opposed to high piston speed with a short stroke engine. As a class—of course there are exceptions—they base all their estimates of engine speed on revolutions only, and no matter how short the stroke is they generally insist on keeping the revolutions the same. The only way to get light machinery to-day, besides varying the ratios of cylinders and number of expansions, is by adopting a short stroke and making up the piston speed by revolutions. But this the American engineer is strongly opposed to. The writer strongly advocates as long a stroke as possible in a sea-going ship, but in a high speed yacht a long stroke is impracticable, as it necessarily means a very heavy engine, which again means less coal, stores, and a reduction of freeboard, and the latter feature, if overcome, means increased weight of hull and still less coal and consumable load. The writer recommends the adoption of twin screws for full powered steam yachts with little or no sail spread, but for a vessel with sail as an auxiliary power it seems that a single screw is quite satisfactory and in some respects desirable. If the draught is limited and the speed high it may be necessary to adopt twin screws in order that the propeller shall agree with the speed of the ship and the speed of the engine. The question of weight of machinery is an unusually important factor in steam yacht design. No matter what speed a yacht of a certain type and size may have, the weight of her hull will be practically the same, especially if she is built to conform to the rules of any standard classification society. If any difference exists, the higher the speed the greater will be the weight of hull, owing to the heavier and larger machinery foundations and the extra stiffening and fore and aft members necessary to

give rigidity to the structure and ability to carry heavy concentrated loads. The displacement of a vessel minus the weight of hull and fittings will give us the weight allowable for machinery, coal and stores.

Let it be required to design a full power twin screw steam yacht of about 1,250 tons displacement with a speed of 17 knots. Suitable proportions for such a vessel are: Length to beam, 7.5, and beam to draught, 2.35 or 2.4, and these proportions would give us dimensions: L. W. L., 232 ft.; beam, 31 ft.; draught, 13 ft.; and assuming a block co-efficient of about .47, a displacement of 1,250 tons. Now the approximate weight of hull and fittings complete for such a vessel of the most modern type would be about 600 tons, and thus 650 tons is available for machinery, coal, complement, outfit and stores. The power to drive the proposed vessel at 17 knots speed under favorable conditions at sea will be about 3,400 I.H.P., and two engines to give this power with a stroke of 33 in. and a piston speed of about 800 ft. to 830 ft. will weigh, with shafting, propellers, piping, spares and all auxiliaries, about 220 tons. Therefore we have a weight of only 430 tons for boilers, coal, fresh water, complement, outfit and stores. If the owner insisted on Scotch boilers worked at natural draft we would find that five single ended boilers to give this power—estimating 10 I.H.P. per sq. ft. of grate area—would weigh, steam up and including all fire room weights, about 320 tons, and as fully 70 tons on a coasting or short distance cruiser would be taken up by water, complement, outfit, stores, etc., only 40 tons of coal could be carried on the designed 13 ft. draught. If Scotch boilers are insisted upon it is quite evident that forced draught will have to be used. If we estimate 17 I. H. P. per sq. ft. of grate surface, which can be obtained with a fair air pressure, and without excessive forcing, we can obtain the necessary power with two very large Scotch boilers, which, with water, a small donkey boiler for auxiliary purposes, and all fire room weights complete, will weigh about 220 tons. Therefore, about 140 tons of coal could be carried. This would probably be sufficient for a cruising coastwise vessel, and as she has good freeboard the vessel, if given large bunker capacity, would be able to cross the Atlantic at a much lower speed by leaving port over draught.

Another problem arises if the owner insists on the vessel carrying coal enough to steam across the Atlantic at say 15 knots speed. To do this such a vessel as here described would have to be equipped with water-tube boilers of the express or small tube type, and smaller high speed economical engines bordering on the torpedo boat destroyer type, for the vessel would have to carry over 400 tons of coal to attain the mean speed. It is a well known fact that as the speed of a vessel increases the ratio of length to beam should increase, and the block co-efficient should decrease. But steam yachts are, as a rule, so very fine that the co-efficient of displacement can remain constant as the speed increases without any appreciable increase in wave making resistance. If we keep the co-efficient of fineness of displacement constant, then, as the speed increase of the weight of machinery per I. H. P. must decrease. As it is not desirable in these days to increase the piston speed of an ocean-going cruiser beyond 800 or 900 ft. per minute, the engine room weights cannot be decreased much, and forced draught and water tube boilers become a necessity in order to fulfil the owner's requirements. Forced draught is not always desirable, and many of the latest British built yachts, although credited with a trial speed of 16 to 17 knots, are only capable of maintaining 13 1-2 to 14 knots when running full speed with natural draught, or under full speed cruising condition. The use of forced draught is advantageous, however, aside from the question of weight. Two boilers working under forced draught must necessarily take up much less room fore and aft than four or five boilers working with natural draught. Two large yachts at present building have the same power. One is to obtain the power with natural draught and the other is to use forced draught. If the coal capacity and dimensions of the vessels were the same the total fore and aft length of machinery would be 102 ft. in the natural draught boat, against 86 ft. in the forced draught boat, which means that the vessel using forced draught has 16 ft. more room fore and aft to be used for the accommodation of the owner and his guests.

To obtain high speed in a steam yacht, the owner has to greatly sacrifice comfort and accommodation. A large steam yacht with good sail spread designed for 12 knots speed under steam alone, natural draft, has a length of 60 ft. amidships devoted to machinery and coal. This same vessel to make a speed of 15 knots natural draft requires a length of 100 ft. for machinery, an increase of 40 ft., or almost twice as much length, to obtain 3 knots more speed, the endurance being the same in each case.

A few years ago the term auxiliary steam yacht seemed almost a misnomer, as the steam power was usually capable of driving the yacht at a speed of more than four-fifths that of a yacht of similar size which was provided with full steam power. Of late years the speed of full powered steam yachts has increased remarkably, until to-day 15 to 18 knots for large vessels and 12 to 16 knots for smaller boats has taken the place of the 12 and 10 knots respectively in the older yachts. The finest auxiliary steam yachts of the large type to-day have a speed under steam alone of about 10 to 12 knots; with speeds of 9 to 11 knots for the medium size and smaller vessels. It would be quite interesting if we could tell just how much an auxiliary yacht under steam would increase her speed by using her sail power, or vice-versa. If a yacht can steam at the rate of say 10 knots and if there is a beam wind which would enable her to make the same speed under canvas without steam, then her speed with the use of both steam and sail power will probably be about 12.5 knots. Supposing the speed under sail to be 12 knots and the speed under steam 8 knots, then the speed under sail and steam combined will be approximately a little over 13 knots.

Auxiliary steam yachts should be fitted with feathering screws. Various methods for feathering have been patented, but the one in most general use is that known as Bevis's.

Most auxiliary steam yachts carry ballast, either water in ballast tanks or else lead, pig iron or solid cement between the floors. If one or the other of these methods for increasing stability is not adopted, great care must be taken in proportioning the dimensions of such

a vessel, for the loss of weight of coal and consumable stores may seriously effect the boat under canvas. The coal should also be used from about the fore and aft position of the center of buoyancy, because, if not there will be the difficulty of trim to contend with, which, although it may not be of much consequence to the full powered steam yacht, might be a serious matter for the auxiliary if she had to work against a foul wind.

The remarkable runs of auxiliary yachts, previously cited, shows their great advantage over unsparred vessels, for they can run thousands of miles under sail alone and thus effect a great saving in coal. The auxiliary yacht requires more beam and usually more depth than the full powered yacht, for a good beam is absolutely essential to give the required high metacentre. The spars, sails and rigging of various steam yachts, with sail power, raise the center of gravity of the vessel from 12 to 18 inches; therefore such vessels must be given good deadrise and increased beam to raise the metacentre accordingly. Whereas 15 to 30 in. initial metacentric height is considered sufficient for steam yachts, 30 to 40 in. is generally considered desirable for auxiliary vessels. As a rule the proportions of auxiliary yachts are such as to insure there being better sea boats than the full powered yachts. At low speeds they are also very economical to drive, but their proportions are not as a rule suitable for higher speeds.

There are few high speed full powered steam yachts to-day that carry sufficient canvas to give them fair speed under sail alone, for as before stated, the proportions adopted for one are not suitable for the other. Nevertheless Col. O. H. Payne's new, American designed, steam yacht *Aphrodite*, is a compromise of the two types. Under steam alone she has attained a speed in dead water of 17 1-4 knots, under natural draft. She has a sustained speed of 15 knots, natural draft, and with over 18,000 sq. ft. of canvas she will be able to jog along at a good gait under sail. She is a single screw vessel, 260 ft. long on the water line, 303 ft. over all, 35 ft. 6 in. beam, and 16 ft. draft, and as she has a very good form for her high speed a number of very complex problems had to be considered in her design. She was constructed at the Bath Iron Works, Bath, Me., from their own designs, C. R. Hascom, General Superintendent, and she has the distinction of being the largest and finest American built steam yacht afloat.

About 12 years ago the British yacht *Amy*, 812 tons, owned by N. B. Stewart, was the largest steam yacht afloat. The American yacht *Namouna*, 740 tons, owned by James Gordon Bennett, came next, and closely following in size was the British yacht *Wanderer*, 708 tons, owned by C. J. Lanhert, which vessel circumnavigated the globe and earned quite an enviable reputation as a deep sea cruiser. Late in 1886 W. K. Vanderbilt's palatial yacht *Alva* was launched at Wilmington, Del., U. S. A., and this enormous barkantine rigged vessel of 1,311 tons, until sunk by the S. S. *H. F. Dimmock* in the Sound, was the largest private owned pleasure craft afloat. Mr. Vanderbilt's present magnificent yacht *Valiant*, already described, was built to replace the *Alva*. In 12 years, therefore, the size of the largest steam pleasure craft afloat has increased three-fold. or from 800 to 2,400 tons.

A COMPREHENSIVE ACCOUNT OF THE SUBMARINE TELEGRAPHS OF THE WORLD.

A very interesting account of the submarine telegraphs of the world, prepared by the Bureau of Statistics, U. S. Treasury Department, is of special interest at this time on account of the importance of our trans-Pacific possessions, and for the purpose of information and ready reference we here publish the article in full:

"The submarine telegraphs of the world number 1,500. Their aggregate length is 170,000 miles; their total cost is estimated at $250,000,000, and the number of messages annually transmitted over them 6,000,000.* All the grand divisions of the earth are now connected by their wires, and from country to country and island to island the thoughts and words of mankind are instantaneously transmitted. Beneath all oceans save the Pacific the universal language which this system has created flows uninterruptedly, and man talks as face to face with his fellow-man at the antipodes. Darkest Africa now converses daily with enlightened Europe or America, and the great events of the morning are known in the evening throughout the inhabited world. Adding to the submarine lines the land-telegraph systems by which they are connected and through which they bring interior points of the various continents into instantaneous communication, the total length of telegraph lines of the world is 835,000 miles, the length of their single wires or conductors 3,500,000 miles, and the total number of messages annually sent over them 365,000,000, or an average of 1,000,000 messages each day.

"In the short half century since the practicability of submarine telegraphy was demonstrated, the electric wires have invaded every ocean except the Pacific. Nearly a score of wires have been laid across the Atlantic, of which no less than thirteen now successfully operate between the United States and Europe, while three others span the comparatively short distance between South America and the African and south European coast lines. Throughout the Indian Ocean, lines connect the far East with Europe and America by way of the Red Sea, the Mediterranean, the western coast of Europe, and the great trans-Atlantic lines. The Mediterranean is crossed and recrossed in its entire length and breadth by numerous cable lines, and the 'Mediterranean of America,' the Gulf of Mexico and the Caribbean Sea, is traversed in all directions by lines which bring its islands and colonies into speaking relations with each other and with South America, Central America, the United States, and thence with Europe, Africa, Asia—the whole world. Along the eastern coast of Asia, cable lines loop from port to port and island to island, receiving messages overland from eastern Europe by way of the Russia-Siberian land lines and forwarding them to Japan, China, Australia, New Zealand, the Straits Settlements, Hongkong, and the Philippines, and receiving others in return. South

*Of this total about 150,000 miles belong to 35 companies operating the commercial cables, which number about 320; the remainder are mostly short lines controlled by governments, and connecting forts, batteries, signal stations, light-houses, etc., the aggregate of governmental lines being about 1,150 and their total length about 20,000 miles. In addition to this the governments of the world hold about 80,000 miles of cable in stock for war purposes, ready to be laid at a moment's notice.

America is skirted with cable lines along its entire border save the extreme south, where they are brought into intercommunication by land lines. Along the entire coast of Africa, cables loop from place to place and from colony to colony, stretching along the entire circumference and penetrating the interior by land lines at various points.

"Every body of water lying between the inhabited portions of the earth, with the single exception of the Pacific Ocean, has been crossed and recrossed by submarine telegraph lines. Even that vast expanse of water has been invaded along its margin, submarine wires stretching along its western border from Siberia to Australia, while its eastern borders are skirted with lines which stretch along the western coast of the two Americas. Several adventurous pioneers in Pacific telegraphy have ventured to considerable distances and depths in that great ocean, one cable line running from Australia to New Zealand, a distance of over 1,000 miles, and another extending from Australia to the French colony of New Caledonia, 800 miles seaward.

"The chief obstacle in the past to the construction of a grand trans-Pacific cable was found in the fact that midocean resting places could not be satisfactorily obtained or arranged for, no single government controlling a sufficient number of suitable landing places to make this seem practicable, in view of the belief that the distance through which messages could be sent and cables controlled was limited. With landing places at Hawaii, Wake Island, Guam, and the Philippines, however, no section of a cable stretching from the United States to Asia and touching at these points would have a length equal to that now in daily operation between France and the United States. The length of the French cable from Brest, France, to Cape Cod, Mass., is 3,250 miles, while the greatest distance from land to land on the proposed Pacific route would be that from San Francisco to Hawaii, 2,089 miles, that from Hawaii to Wake Island being 2,040 miles, from Wake Island to Guam 1,290 miles, from Guam to Manila 1,520 miles, and from Manila to the Asiatic coast 630 miles. While the depth of the Pacific is somewhat greater than that at which any cable has been laid, the difference between its depth and the greatest reached by cables in the Atlantic would be very slight, the cable recently laid from Haiti to the Windward Islands being in 18,000 feet of water, while the greatest depth between San Francisco and Hawaii is 18,300 feet, and the greatest depth between Hawaii and Manila is estimated at 19,600 feet, though this estimate is yet to be verified by detailed soundings. Otto Krummel, who was the first to discuss the bathymetric data and calculate the area and volume of the various oceanic basins, puts the mean depth of the Pacific at 2,160 fathoms, against 2,040 for the Atlantic, in which cables have already been so successfully laid, and later researches and actual soundings, while they have developed extreme depths at certain points in the Pacific, have not, in the opinion of experts, been such as to warrant the belief that the depths along the proposed line would be considerably greater than those in which cables have been already successfully laid and operated.

"The developments in the construction, laying, and operating of submarine cables and in their availability for general public use have quite kept pace with their extension throughout the civilized world. From a mere gutta-percha-coated wire, the submarine conductor of electricity has developed in a half-century into a great cable having a central copper core surrounded by numerous layers of non-conducting material and protected by steel wire wound spirally about it, and in turn further protected by waterproof and insect-proof wrappings. From a steamer-towed open barge, the facilities for laying have developed to a fleet of nearly fifty steam vessels, with every facility for laying, picking up, splicing, and repairing the cable lines. From a speed rate of three words per minute, which was made on the first transatlantic cables, the speed of transmission has been accelerated to fifty words per minute, and even more than that with the automatic transmitters now coming into use with cable lines, while by the duplexing of the cables their carrying capacity is doubled. From a cost to the sender of $100 per message, which was originally charged on the first transatlantic cables, the rate from New York to London and the great cities on the continent of Europe has fallen to 25 cents per word. From several hours required for the transmission of a message and receipt of a response, the time has been so reduced that messages from the Executive Mansion to the battlefield at Santiago were sent and a response received within 12 minutes, while a message sent from the House of Representatives in Washington to the House of Parliament in London in the chess match of 1898 was transmitted and the reply received in 13 1-2 seconds.

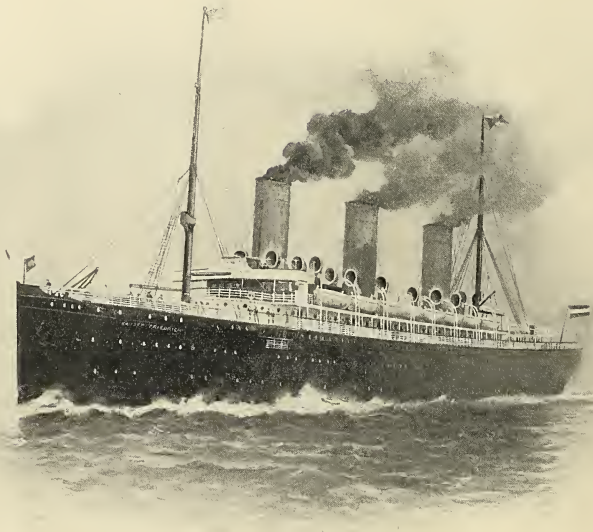
"The effect of this ready and inexpensive method of transmitting thoughts and words from continent to continent throughout the civilized world is shown in the rapid development of international commerce since it began. The first successful cable lines between the United States and Europe were put into operation in 1866. In that year our commerce with Europe amounted to $652,232,289; in 1876, to $728,959,053; in 1886, to $898,911,504; in 1896, to $1,091,682,874, and in 1898, to $1,279,739,936, while our commerce with the whole world, which in 1866 amounted to $783,671,588, had by 1898 reached the enormous sum of $1,847,531,984.

"With this evidence of the advantage of prompt communication between commercial centers desiring an interchange of their products, it may not be improper to call attention to the fact that the United States now obtains but a small proportion of the commerce of Asia, which it is at present only able to reach through the long and devious submarine and land telegraph lines across the Atlantic, the continent of Europe, the Mediterranean, the Red Sea or the Persian Gulf, the Indian Ocean, land lines across India, cable lines again by way of the Straits Settlements, and thence along the Asiatic coast and among the islands of Oceanica. The commerce of the countries of Asia and Oceanica lying commercially adjacent to the Philippine Islands amounts to more than $2,000,000,000 annually, their imports alone averaging $100,000,000 a month, or $1,200,000,000 per annum. Of this enormous market the United States at present obtains less than 6 per cent, despite the fact that the imports into the countries in question are largely composed of the classes of arti-

cles produced in the United States and offered for sale by her manufacturers and merchants. With a direct cable communication across the Pacific, direct water communication through a Nicaraguan canal, and an increase in the number and capacity of American steamships, it seems not improper to suppose that a material addition might be made to the share obtained by the United States in the trade of that part of the world."

Atlantic Liner Kaiser Friedrich.

Flying the house flag of the Hamburg-American line the magnificent new liner *Kaiser Friedrich* came into the port of New York recently, and after the usual stay took on passengers and cargo and sailed on schedule



S. S. KAISER FRIEDRICH FLYING THE FLAG OF THE HAMBURG-AMERICAN LINE.

on her return trip October 17. No speed records were broken coming over, nor does it seem likely that any will be by the new vessel. We used the adjective (magnificent) advisedly, for taking the vessel as a whole in comparison with other liners she is truly a magnificent ship. That she has not come up to expectations is due, in great part, to what might at first seem to be details not of the first importance. In fact this vessel is an example—not the first by any means—of what may be gained or lost by the treatment of details of design.

The *Kaiser Friedrich*, as most of our readers are doubtless aware, was built at Elbing for the North German Lloyd Co., and made her first trip in the summer of 1898. She had had no trial at sea before starting on her maiden voyage, and her time across was very disappointing to the company for which she was built. Owing to defects which developed in the machinery the vessel had to be slowed down the greater part of the voyage, and her average speed across was less than eighteen knots. At the time we published an account of this trip, and referred in detail to the causes of delay. These were not due to imperfect workmanship or material, but to fundamental features of design in the machinery equipment. The North German Lloyds finally returned the vessel to the builders, and are understood to have subsequently offered a price for the vessel which the builder would not accept. Other offers were made for the liner, and finally she was acquired by the Hamburg-American line at a price which is said to have been close to 7,500,000 marks. The terms of the sale have not been announced, but the vessel is reported to have been taken over on a guarantee.

When the *Kaiser Friedrich* came out she was fitted with air pumps driven direct by the main engines. These were removed and independent air pumps substituted. Provision was also made for additional receiver space in the engines by the attachment of outside receivers on top of the cylinder castings. In this way the difficulties in the engine room were gotten over. The difficulty of holding steam at the working

pressure was sought to be overcome by removing the original boiler tubes, which were bottle-necked in the back connections, and substituting for them tubes with coned ends. A change has also been made in the system of draft, and, instead of forced draft, natural draft will probably be employed hereafter.

This is not the first instance in which a liner built for one line was afterward transferred permanently to another, and while the *Kaiser Friedrich* will not likely be classed as a flyer, she ought to find a top place in the 19-knot class. She will still be a fast boat, and as she was built primarily for passenger service—the cargo-carrying capacity being extremely small—and fitted up luxuriously with every possible device for the comfort and convenience of ocean voyagers, she is likely to become a favorite. To many indeed it would be a source of satisfaction that they were traveling in a boat that was not being driven to the utmost limit.

For convenience we repeat her dimensions, as follows: Length, 600 ft.; beam, 64 ft.; depth, 41 ft. from keel to upper deck; gross tonnage, 12,000 tons; and displacement at 28 ft. draught, 17,000 tons. The fine appearance of the *Kaiser Friedrich* at sea is shown in the accompanying reproduction of a recent photograph.

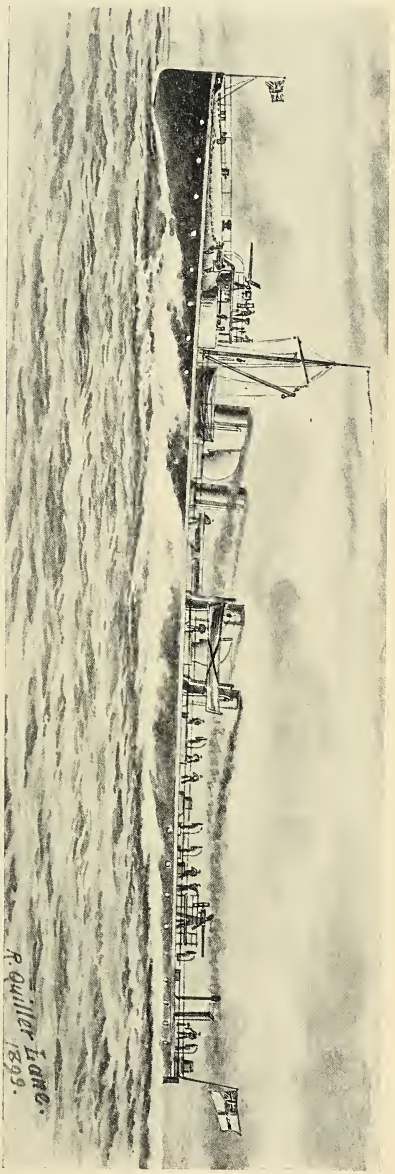
H. M. S. Viper—Turbine Driven Destroyer.

In our last issue we gave an account of the progress which has been made in the application of Parsons' steam turbine to marine propulsion, and referred to two torpedo boat destroyers under construction in England to be fitted with the turbine form of propelling engines. One of these boats is for the British navy, and is named the *Viper*. She was launched September 6 from the works of Hawthorne, Leslie & Co., Newcastle-on-Tyne, and we are now enabled to present a sketch of the new flier as she will appear at top speed—this is given as not less than 35 knots. The exact dimensions of the vessel are not yet public property. She will displace, however, about 325 tons, and her builders report that the engines are expected to develop about 12,000 horse power. She will have four sets of propelling turbines, and four separate shafts, with two propellers on each shaft. Following are the weights which have been announced: Engine room, 117,152 lb.; boiler room, 225,680 lb.; shafting, 17,360 lb.

A lower estimate for the power is apparently made by the British naval authorities, for in a paper read by Sir William White, Chief Constructor of the British navy, before the famous British Association, he refers to the boat in these terms:

"The experiment which the Admiralty is making is not on a small scale as regards power. Although it is made in a destroyer, about 10,000 horse power will probably be developed, and a correspondingly high speed attained. It may well happen that from this experiment very far reaching effects may follow."

Should the *Viper* attain a rate of speed of 35 knots this would only equal the results claimed by Schichau, the German builder, who reported a speed in excess of 35 knots, with reciprocating engines, in the case of the four destroyers (200 tons disp., 6,500 I.H.P.) for the Chinese Government. Our readers will recollect that we published in our issue of March last a view of one of these torpedo boat destroyers steaming at top speed.



SKETCH OF H. M. S. VIPER, TURBINE DRIVEN DESTROYER, BUILT TO STEAM AT THE RATE OF 35 KNOTS—DISPLACEMENT, 325 TONS; I. H. P., 10,000.

APPLICATION OF THE THREE-WIRE SYSTEM TO MARINE ELECTRIC PLANTS.

BY CECIL P. POOLE.

The existing absurdity of two "standard" voltages, incommensurate with each other, for marine electric lighting and power plants has been the object of considerable comment, now mildly critical, again timidly argumentative, but the writer has not seen any definite, clear-cut suggestions for a logical standard to supplant the two now in use. As the question is a perfectly simple one, involving only a few considerations based upon well-known and firmly established engineering principles, it seems rather remarkable that the present anomalous state of affairs has survived so long, and yet more remarkable that no one has taken action, at least on paper, toward a reform.

Two opposing conditions control the matter: The electromotive force of a marine system cannot be very high because of the difficulty of permanently insulating the conductors and their inaccessibility on shipboard; and also because there is a well-defined limit to the economical voltage of incandescent lamps; on the other hand, very low potential, such as 50 volts, involves excessive outlay for conductors, because their weight increases as the square of the voltage decreases, for a fixed load in watts, distance in feet and percentage of "drop" in the wiring. Thus, if C represents the load in amperes; W the load or rate of work in watts; E the electro-motive force of the system; F the distance from end to end of a feeder, in feet; V the drop in volts and d the diameter of the wire in mils, we have the following relations:

$$\frac{21.2CF}{d^2} = \frac{21.2WF}{Ed^2} = V.$$

and as the drop in percentage is $\frac{100V}{E} = D_{\%}$,

$$\frac{2120WF}{E^2d^2} = D_{\%}.$$

and consequently, $\frac{2120WF}{E^2D_{\%}} = d^2. \quad \therefore d^2 \propto \frac{1}{E^2}.$

As 125 volts is a standard figure for shore apparatus, and generators, motors, lamps, etc., made for this potenial are purchasable in open market, this seems a rational standard for marine work. The insulation of conductors distributing current at this pressure is a simple, every-day problem, even when the wires are located in damp places. For ordinary marine plants, a generator giving 125 volts at the bus bars and supplying a wiring system at a "drop" of 5 volts, leaving 120 volts available at the load, is as near ideal as one can expect perverse inanimate things to approach.

Leaving aside the gain in cost of conducting system that is afforded by 125 volts electromotive force as compared with 80 volts, the former standard has everything in its favor with the bare exception of its application to searchlights.

Should there be several arc lamps in service, requiring individual control, these can be provided for by running three-wire circuits from the nearest convenient point on the main circuit, or from the switchboard, balancing the two sides of the three-wire circuit by means of two motors coupled rigidly as to shafts and connected in circuit, as shown by Fig. 1. The motors have differential field windings, the series coils, Sa, Sb, being connected in opposition to the shunt windings Fa and Fb. These latter are connected each in shunt to the other's armature and series coil. The action is as follows: As long as the load is equal on both sides of the three-wire system the two motors run light. Should the load in a increase beyond that in b, the voltage will drop slightly at the terminals of Fb, causing B to speed up and drive A as a dynamo, restoring the E.M.F. This effect is enhanced by the heavier current from a flowing across from the neutral to b through the demagnetizing field coil Sb, still further weakening the total field of B and increasing its speed.

This action is entirely automatic, either motor speeding up and driving the other as a dynamo the instant the E.M.F. drops on the opposite side. This arrangement is by no means complicated, and can hardly be called "special" now-a-days. Motor dynamos in all sorts of combinations are available and sufficiently

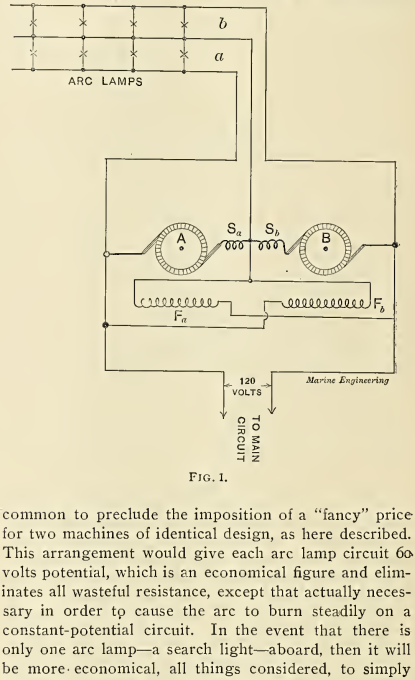


FIG. 1.

common to preclude the imposition of a "fancy" price for two machines of identical design, as here described. This arrangement would give each arc lamp circuit 60 volts potential, which is an economical figure and eliminates all wasteful resistance, except that actually necessary in order to cause the arc to burn steadily on a constant-potential circuit. In the event that there is only one arc lamp—a search light—aboard, then it will be more economical, all things considered, to simply connect it across the 120-volt circuit in series with dead resistance than to either use a low potential plant or put in a motor-dynamo and convert the E.M.F. to 60 volts, as suggested recently by another writer.

Where the plant is of some magnitude the writer would strongly advocate the use of a 250-volt dynamo in connection with a complete three-wire system throughout the ship, with a drop of 10 volts in the outer wires—5 volts in each. It is very little more trouble to insulate 250 volts than to insulate 125 volts, and when

electric motors are used to drive auxiliaries, or even if there is not a motor aboard, and the lighting plant comprises 1,000 lamps or more, the higher potential is immeasurably preferable. A favorite argument against the three-wire system for ship work is the alleged increase in complication. This is a perfectly specious plea; if there is anything that is more complicated in continuous-current work than some of the switchboard arrangements now in use aboard ship, the writer hopes to be spared a struggle with it.

The two sides of the three-wire system may be balanced in a diversity of ways. The two-motor arrange-

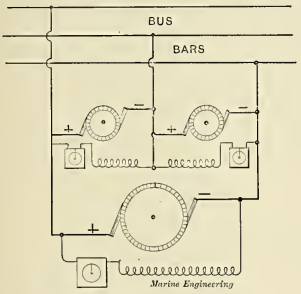


FIG. 2.

ment shown in Fig. 1 may be used in the dynamo room between the main dynamo and the switchboard. Or two ordinary dynamos driven by an engine common to both may be connected with the main 250-volt dynamo, as shown by Fig. 2. These can be each of one-fifth to one-fourth the size (output) of the main dynamo if the plant is properly laid out.

A third plan, and one that the writer greatly prefers, is to employ an ordinary four-pole generator with the field windings divided into two separate circuits, and so connected up that the polarity of successive magnet

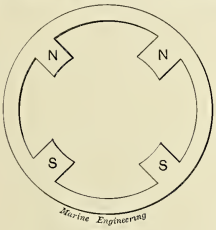


FIG. 3.

poles does not alternate regularly, in the ordinary manner, but is distributed as in Fig. 3, with the two "north" poles next each other and the two "south" poles given a similar relation. The armature must have an ordinary multi-path Gramme winding and four brushes, and the circuits would be connected as in Fig. 4. Half of the field windings (the coils on one north pole and one south pole) would be supplied from one side of the three-wire system and the other half from the other side, and each would have a rheostat in series with it for regulation purposes.

Then the rheostat, R_a, would regulate the pressure across from n to a and the rheostat, R_b, would regulate that across from n to b, each entirely independently of the other. And the machine could be compounded just as an ordinary dynamo would be, the series coils on the right-hand pair of poles being in series with b and those on the left hand pair of poles in series with a. In short, each half of the machine will act exactly as a separate dynamo with relation to the other half and the circuit, under normal working conditions, irrespective of the ratio between the two loads.

This arrangement divests the three-wire system of what little "complications" it usually involves—the use of two dynamos (and usually two engines) for all loads, however small—and makes an electromotive force of 250 volts entirely practical without departing from the common staple type of equipment which is found in daily use everywhere. Lamps, sockets, switches and other fittings of standard types are available for use on

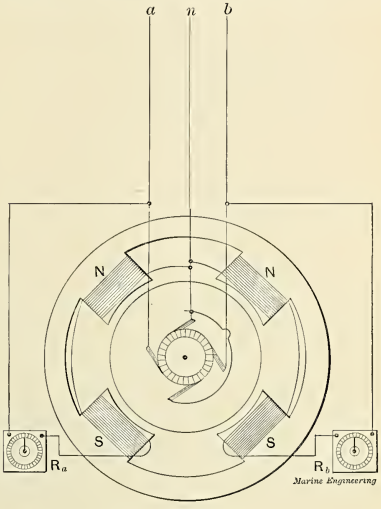


FIG. 4

each side of the system, and a high economy in wire is obtainable without any sacrifice in convenience of control or an appreciable complication.

The same arrangement of the dynamo connections could be applied to a 125-volt system having arc lamps connected in, by using the two outer wires as the regular circuit everywhere except at the arc lamps. A middle wire would be run out to these, as shown in Fig. 5. Pilot wires would extend from the switchboard to the ordinary center of distribution, and a volt meter of 125 volts range or over would be supplied by these; other pilot wires would connect the three-wire group with two voltmeters, each of 75 volts range or over. Once the dynamo is brought up to the proper E.M.F., further hand regulation will be unnecessary, if the machine is properly compounded. In the event that the arc lamps were used intermittently and a plain shunt

wound generator employed, the arrangement shown by Fig. 6 would render regulation more convenient. With the arc lamps out of service the potential would be regulated by means of the rheostat, *R*. When the arc lamps were in service the rheostats *Ra* and *Rb* would

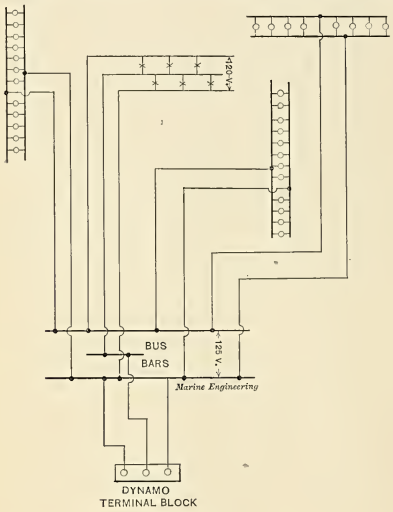


FIG. 5.

have to be used, each to regulate for its own side of the arc lamp wiring. The middle rheostat, *R*, would then not need to be touched.

In case search lights or other arc lamps were to be

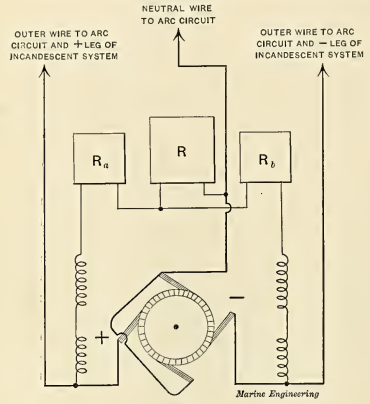


FIG. 6.

used on the 250-volt three-wire system, shown by Fig. 4, a combination of this and the balancing system in Fig. 1 would afford all necessary flexibility. Fig. 7 shows the elements of such a combination system. The arc lighting mains with the balancing motors form a complete sub-system which may be connected with the main system on either side of the neutral wire and at any point. It would be manifestly better engineering to carry the leads *a* and *b* all the way back to the switchboard, where they could be connected and disconnected to and from the bus bars at will.

The conductors for a system such as those shown by Figs. 1 and 5, the dynamo E.M.F. being 125 volts and the drop 4 per cent would cost just 45 per cent of the amount required for conductors in an 80-volt two-wire system under identical conditions, so that the saving in cost of copper would much more than pay for the balancing motors in Fig. 1, if the plant were of any magnitude. The conductors for a system like Fig. 7 would only cost *one-sixth* as much as those for an 80-volt system, including the neutral wire, which is assumed to have a cross section equal to that of each outer wire. Besides this saving there is the further

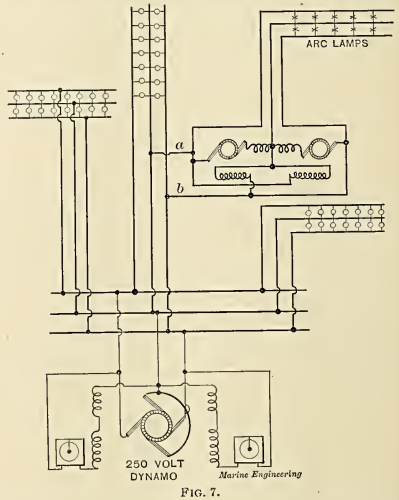


FIG. 7.

advantage that no dead resistance other than that necessary for regulation is required in series with the arc lamps in any of the systems here proposed, whereas in the 80-volt system there is a dead loss of from 25 per cent to 35 per cent due to resistance coils which must be employed to cut down the electromotive force.

Lieutenant Poundstone, U.S.N., has been placed in charge of the naval exhibits at the Paris Exposition. The U.S.S. *Prairie* will leave about the middle of this month for Havre with a number of exhibits which are to be made by the United States Government. One of the chief exhibits of the Navy Department will be a model of the battleship *Maine*.

It is reported that a corporation to be known as the Buffalo Dry Dock Co. has secured control of the Mills Dry Dock Co., Buffalo, and will establish there a plant capable of building large lake steamships.

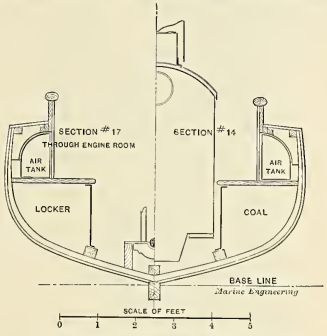
Recent Steamship Losses by Fire.

Fire destroyed the small wooden propeller *Nutmeg State* in Long Island Sound early on the morning of October 14, and about a dozen persons lost their lives. The vessel belonged to a line trading between Bridgeport, Conn., and New York. The boat was about five miles from Execution Light when fire was discovered in the vicinity of the base of the stack. The passengers were at once aroused and the crew set to work to extinguish the flames, but to little purpose. When it was apparent that the vessel could not be saved the boats were ordered lowered. Due to the excitement and terror of the passengers, and the probable unfamiliarity of the deckhands with rescue work, all semblance of discipline was lacking, and boats were capsized. Fortunately at this time the Hartford Line steamer *City of Lawrence* and the steam yacht *Kismet* had sighted the burning vessel, and, coming up, saved many lives. Those taken on board these vessels were treated with great kindness. It was then decided to try and beach the *Nutmeg State*, and the engineers and firemen remained on watch until the vessel touched bottom at Sands Point, Long Island. Their devotion to duty under the circumstances deserves recognition. Charges of cowardice against the crew were made by some passengers and denied by others. The facts go to show that they acquitted themselves well to the best of their ability, and the criticisms made doubtless came from persons who at the time were too excited to form any correct judgment. The *Nutmeg State* was about 200 ft. in length and 100 tons gross tonnage.

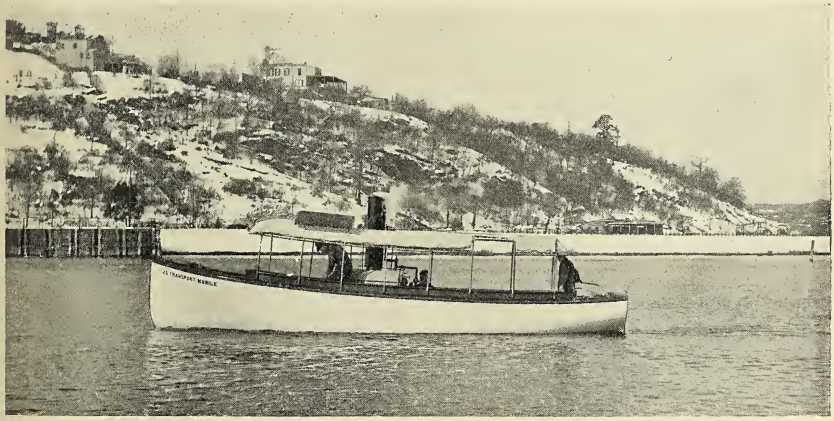
After reaching her dock in the East River, New York, from Galveston, Texas, with a cargo of cotton and jute, the Mallory Line steamship *Leona* was found to be on fire. She had come in with passengers, who were landed shortly before the flames appeared, and then the New York fire department was summoned. Water was pumped into her holds until she listed over to starboard and sank to the mud bottom. This vessel is apparently a hoodoo, having had a somewhat similar experience in May, 1898, when on a voyage to Galveston. On that occasion several steerage passengers were burned to death. The vessel will be raised and repaired.

Steam Tenders for Army Transports.

When fitting out the fleet of ocean transports for the United States Army Transport Service, the authorities decided to equip the vessels with powerful steam tenders. An order for a number of these boats was accordingly placed with the Gas Engine & Power Co., and Charles L. Seabury & Co., Consolidated, Morris Heights, New York city, and by the courtesy of the builders we are able to here present drawings and photographs of the type.

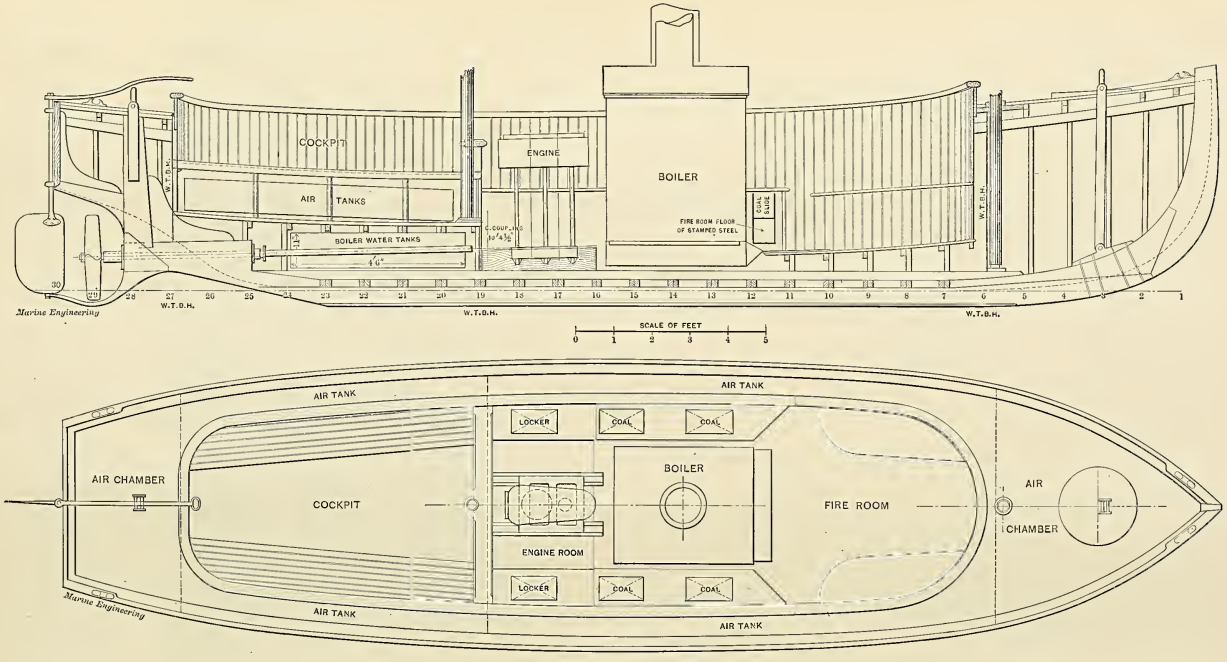


CROSS SECTIONS TRANSPORT TENDERS.



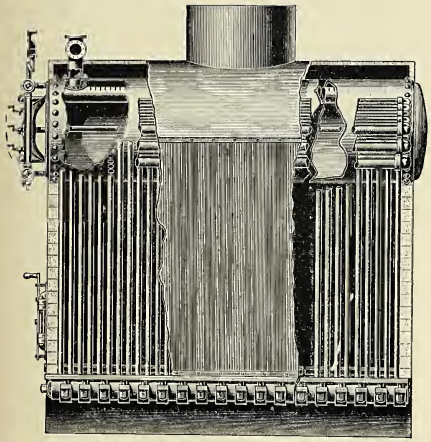
TYPE OF STEAM TENDER ADOPTED FOR U. S. ARMY TRANSPORT SERVICE.

Details of construction can readily be gathered from an inspection of the accompanying scale drawings. The over-all dimensions are: Length, 30 ft.; beam, 8 ft.; depth, 4 ft. 1 in., and draught, mean, 2 ft. 2 in.

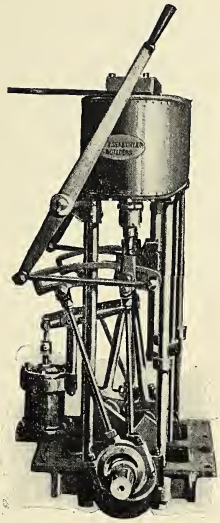


SCREW STEAM TENDERS FOR U. S. ARMY TRANSPORT SERVICE, BUILT BY THE GAS ENGINE & POWER CO. AND C. L. SEABURY & CO., CON., MORRIS HEIGHTS, N. Y.

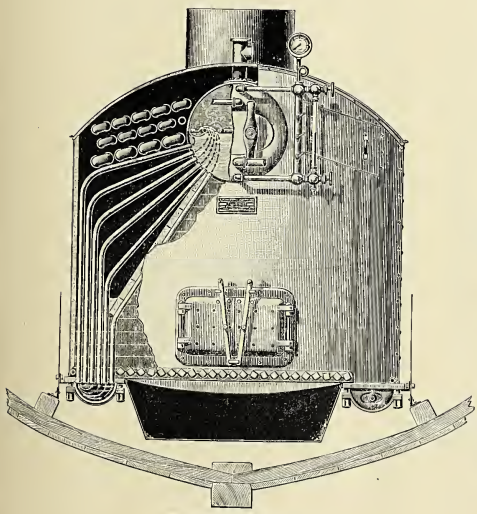
They are fitted with three watertight bulkheads, and are made exceptionally strong, the models being especially adapted for sea-going qualities, with good depth, beam and full lines throughout. The machinery includes a vertical fore and aft compound engine of the builder's standard pattern, with cylinders, 4 in. and 8 in. by 7 in. stroke, and a high-pressure Seabury water-tube boiler. The power is greater than is usually placed in a hull of these dimensions. On the forward deck there is a foundation where a one-pounder rapid fire gun can be mounted. It will be noticed that air tanks are fitted fore and aft for buoyancy, and masts are provided for a lug rig. The boats were built to withstand very rough service, and we are informed that they have given very great satisfaction to the transport service.



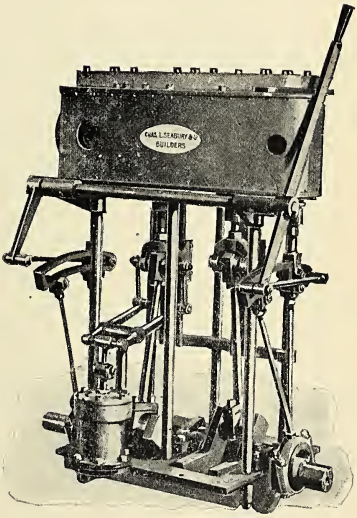
SIDE ELEVATION—CASING PARTLY REMOVED.



END ELEVATION.



WATER TUBE BOILER.



COMPOUND ENGINE.

MACHINERY OF THE SCREW STEAM TENDERS FOR U. S. ARMY TRANSPORT SERVICE.

RESUME OF THE LAKE FREIGHT SITUATION—CAUSES AND EFFECTS.

A most remarkable condition of affairs has come into existence within the past few months in the vessel and shipping business on the Great Lakes. The unusual activity in all branches of business, following on several years of depression, coupled with the almost universal tendency for consolidation in all of the leading industries, and, in the cases of the iron and steel industries, for the manufacturer to own and control his product from the mine to the finished article, has worked such wonderful changes in the transportation end of the operation that what the final results will be the most experienced cannot predict.

The vessel business on the Lakes has been carried on for the past few years on the very scantiest of margins. At the opening the present season's navigation promised nothing out of the ordinary, but as the miners of iron ore held off from selling their 1899 product until an unusually late date, all owners of "wild" tonnage grew uneasy and were very prompt to close early contracts at 60 cents a ton from the head of the Lakes to Lake Erie ports. As a consequence a large number of boats were tied up for the season by charters on this basis. This charter price was established by a deal entered into between the Oliver Mining Co. (Carnegie interests) and the Rockefeller interests, in which the Oliver Mining Co. leased certain mining properties from Rockefeller for a term of fifty years on a fixed royalty, and with an agreed minimum yearly production of about 1,400,000 tons of ore, which they bound themselves to transport over railroads and in vessels controlled by the Rockefeller interests. The rate for this transportation was to be fixed at the starting of each season by agreement if possible, or, if an agreement could not be arrived at, then to be determined at the close of the season by reference to the average price paid by other shippers during the season. Very shortly after the opening of this season's navigation, however, the entirely unlooked for demand for finished iron and steel products, also the consolidation of such interests as have made up the Federal Steel Co., the American Steel & Wire Co., the Republic Iron & Steel Co., and others, and the very sharp advance in prices all along the line changed the conditions materially, and those vessel owners who had not tied up their boats with contracts early in the season began to stiffen up on charter prices and to make larger profits than they had known in years. As a part of the consolidations referred to, the Federal Steel Co. and the American Steel & Wire Co. acquired large mining interests, and at about the same time the Oliver-Carnegie interests also acquired additional large mining properties.

It very soon became apparent to all the larger manufacturers of iron and steel, that if they wished to properly protect their interests they must not only control the blast furnaces and mills, but they must also control the mines and the transportation from the mines to the furnaces. As stated, the Federal Steel Co. already controlled large mine interests, and they also owned, through the Minnesota Steamship Co., a fleet of about sixteen vessels. This fleet was insufficient to handle either the output of their mines or the requirements of their furnaces, and the company promptly placed an order with the Chicago Shipbuilding Co. for a steamer and two tow barges of the largest type. This was followed, very shortly, by the purchase, by the same corporation, of two large steamers then under construction at the Lorain yard of the Cleveland Shipbuilding Co. for A. B. Wolvin and others, and by the sale of the S.S. *Clarence A. Black*, just finished at the same yard, to Pickands-Mather & Co. (representing the same interests), all at considerable advance over the original contract prices of the vessels.

At this time there was sharp competition between the Federal Steel Co. interests and the American Steel & Wire Co. for the control of the fleet of five large steamers owned and operated by the Zenith Transportation Co. Finally the American Steel & Wire Co. succeeded in buying the boats at an advance of 25 per cent over their original cost. About this time it was rumored that Mr. Wolvin, who had built and managed the Zenith Transportation Co.'s fleet, was about to leave the Great Lakes, and, in company with James J. Hill, of the Great Northern Railway, would establish a new trans-Pacific steamship line. This, however, was very shortly proved to be incorrect by the fact that Mr. Wolvin resumed the management of the Zenith fleet for the American Steel & Wire Co., and by his placing an order with the American Ship Building Co. (the new consolidation of Lake shipbuilders) for four 500 ft. steamers, the first of this size to be built on the lakes—these boats being presumably also for the American Steel & Wire Co. interests. Almost at the same time the Bessemer Steamship Co. (Rockefeller interests) again entered the field, as builders, by placing an order for a steamer and two tow barges of the largest type. Mitchell & Co., individual owners, also placed orders for three steamers, each to have a carrying capacity of over 5,000 tons.

These moves, coming as they did in rapid succession and tending to concentrate the tonnage in the hands of a few large ore shippers, left the smaller shippers in an unlooked for predicament, as some of them had a considerable amount of tonnage to be moved, and as the demand for tonnage in other lines of traffic had become unusually sharp. The fierce scramble for boats that ensued was unprecedented, and rates advanced steadily until the almost prohibitive rate of $2.00 a ton on ore from the head of the Lakes to Lake Erie ports was reached. This remarkable advance was not confined to ore rates alone, but was reflected in all lines of shipping, and especially so in grain and lumber rates, and so stimulated vessel values that many boats have since changed ownership at prices quite unlooked for early in the season—and by many never looked for again on the Lakes.

Some of these changes have, indeed, been quite remarkable: for instance, the S.S. *Clarence A. Black*, previously referred to, was built under contract for Detroit parties for $210,000. When completed she was immediately sold at an advance of $30,000, and has again changed hands recently at a price in the neighborhood of $325,000. The S.S. *Angeline*, only recently completed at the Wyandotte yard, changed hands when only about one-third built, at a substantial bonus to her owners, and the same parties who sold her have since contracted for two more vessels at prices considerably in advance of what they received for the *Angeline*.

So much for what has led up to the present situation; now what of the present conditions and of the future? The question is a difficult one, and the battle now on is between giants. As previously noted, the early arrangement made between the Carnegie-Oliver interests and the Rockefeller interests provides for the carrying of about 1,400,000 tons of ore annually for the Carnegie people, by the Rockefellers, at a rate to be adjusted each year, and the rate for the present year was fixed early in the season under the most unpromising conditions. It is, of course, to the interest of the Rockefellers, who own mines and vessels, but do not manufacture, to keep transportation rates up to the highest point, especially during the life of their agreement with Carnegie; while on the other hand it is to the interest of the Carnegie iron masters, with their mines and mills, to keep the cost of transportation down to the minimum. The twenty-four vessels owned by the Rockefellers have an annual carrying capacity of about 2,400,000 tons, considerably more than enough to cover their Carnegie obligations, though not quite enough to carry all the ore produced from the Rockefeller mines, and far from enough to carry the remainder of the 4,500,000 to 5,000,000 tons which it is estimated Carnegie will use during the coming year.

It is still earlier than usual for the chartering for next season, but as soon as the situation here described begin to be realized there was immediately started a sharp competition between these two giant interests to control the vessels necessary to cover this remainder of the Carnegie ore. For weeks past all sorts of rumors have been in circulation of sales of vessels at fabulous prices and of charters for the season of 1900 at unheard of rates. Some of these rumors have, however, become known facts. The Rockefeller interests, after the sharpest competition, have secured by actual purchase the entire American Steel Barge Co.'s fleet of thirty whaleback vessels, with an annual carrying capacity of about 1,500,000 tons. These interests have also secured by charter for the season of 1900, at a rate of $1.25 per ton, eight vessels owned by Mitchell & Co., with a carrying capacity of about 960,000 tons in a season, and a large number of single vessels and small fleets amounting in all to probably nearly another 1,000,000 tons per year. These vessels, in addition to the twenty-four boats already owned by the Bessemer Steamship Co., give the Rockefellers a total carrying capacity for the season of 1900 of something over 5,500,000 tons of ore. This is in the neighborhood of 2,000,000 tons more than the total output of the Rockefeller mines, including the 1,400,000 tons to be carried for the Carnegie-Oliver people under their contract, and would seem to tie up enough of the "wild" tonnage of the Lakes to force Carnegie into giving the Rockefellers most of his surplus ore to carry and at rates which they might dictate, both on the surplus and on the 1,400,000 tons contracted for.

The Rockefellers while engineering this deal undoubtedly took into consideration the fact that the Lake ship yards were already fairly well filled with work, and the apparent impossibility of their being able to get the material for building any more vessels. They have, however, seemingly underestimated the strength of their opponent, and they were unquestionably surprised at the announcement a few days ago that the Carnegie interests had made a contract with the American Ship Building Co. for six of the very largest type of steamers for delivery early in 1900, they agreeing to furnish all of the material themselves in order to enable the shipyards to complete the vessels. The position of advantage seems to have changed, and the question now is "what will Rockefeller do with all his surplus tonnage if Carnegie succeeds in covering his surplus ore?" The situation is interesting, and the final outcome of this conflict will be watched with the closest attention by all interested in Lake marine matters.

In the meantime the advantages to the small individual owners and to the shipbuilders of the Lakes have been many, and the profits on this and the next season's operations will be such as were never expected to be realized again on the Great American Lakes, and will dim the stories of the palmy days of long ago.

There are now building and under contract at Lake yards twenty-five steel vessels, valued, approximately, at $7,500,000. Twenty-two of these are under contract with the American Ship Building Co., and are described as follows: Four 500 ft. steamers of about 8,000 tons carrying capacity each, for A. B. Wolvin and the American Steel & Wire Co. interests; two Welland Canal size steamers of about 3,000 tons capacity for Mr. Wolvin and others; six steamers of about 7,600 tons capacity each for the Carnegie-Oliver interests; one steamer and two tow barges of a total capacity of 21,000 tons for the Bessemer Steamship Co. (Rockefeller interests); one steamer for Mitchell & Co. of 6,000 tons; two tow barges for the Minnesota Steamship Co. of over 7,000 tons each; one Welland Canal steamer of 3,000 tons for R. R. Rhodes; two steamers of 6,000 tons each for Eddy Bros., and a sidewheel passenger boat for the Detroit & St. Clair River Excursion Co. The three vessels building at yards outside of the combination are: a package freighter of 5,000 tons for the Lehigh Valley Transportation Co., building at the Union Dry Dock Co. yard at Buffalo, and two Welland Canal size steamers of 3,000 tons each, one building at Craig's yard at Toledo for Arthur Hawgood, and the other at the Jenks Ship Building Co. plant at Port Huron on yard account.

The only yard on the Lakes now building wooden boats is that of Capt. James Davidson at West Bay City, Mich., where there is now one large wooden steamer on the stocks, and where at least two more large vessels will undoubtedly be built within the next few months.

What might be termed a contest for the ownership of steamships of more than 10,000 tons gross is now going on between Great Britain and Germany. The former now owns about a dozen of such vessels afloat and the latter nearly two dozen; but next year the conditions may be changed, as a considerable number of steamships of the largest size are now under construction for British owners.

It is reported that the transatlantic liner *City of Rome* has been secured by the British Government and will be put into service as a hospital ship during the Transvaal war.

BOILER ARRANGEMENTS OF RECENT BRITISH AND FOREIGN CRUISERS.*—I.

BY F. T. MARSHALL, MEMBER.

During the past few months the company with which the writer is connected have completed the machinery of several vessels of the cruiser class, which differed so noticeably in the type of boiler fitted that he thinks some comparison of the system used, and some description of the arrangements adopted, may prove of interest to the members of the Institution.

The vessels referred to are H.M.S. *Andromeda*, built at Pembroke Dockyard; H.R. Portuguese M.S. *Don Carlos I.*, built at Elswick; and H.I. Chinese M.SS. *Hai Tien* and *Hai Chi*, sister vessels, also built by the Armstrong Company. With this paper a comparative table will be found, giving particulars of the power, heating surface, grate area, space occupied, and weight of the boiler arrangements of these vessels.

Owing to the courtesy of Sir John Durston, the writer has been able to add similar information regarding H.M.S. *Hermes*. This vessel is one of the latest second-class cruisers in the British service, and in size more nearly resembles the *Don Carlos* and *Hai Tien* than the *Andromeda* does. Particulars are also added of H.M.SS. *Eolus* and *Pallas*, which are typical second and third-class cruisers with cylindrical boilers.

BOILER ARRANGEMENTS.

The boiler installation of the *Andromeda* consists of thirty Belleville boilers fitted with economizers. These boilers are arranged in four watertight compartments, there being a separate funnel to each group. The stokeholds are fitted with the necessary arrangements for closing in, fans being supplied to work them under pressure if necessary. Each boiler-room is also supplied with a furnace air-pumping engine to supply air in jets above the fire-grates, and also in the combustion chamber under the economizer.

The arrangement of the boilers of the *Hermes* consists of eighteen Belleville boilers with economizers. These are arranged in three watertight compartments, each group having its own funnel.

The boiler arrangement of the *Don Carlos I.* consists of twelve Yarrow-type boilers arranged in two watertight compartments with two funnels. It is of interest as being the largest installation of small-tube water-tube boilers which has yet been tried at sea, and it may here be mentioned that all the trials passed off without the slightest hitch and no difficulties were experienced. The forced-draft fittings are on the closed stokehold system, there being four fans to each boiler compartment. In addition to the air which passes through the automatic draft plates at the front of the grate, a further air supply is given to the sides and back of the grate, by means of automatic flaps fitted in a screen built closely round the boiler front and fitting to the floor, sides, and top of the stokeholds.

The boiler arrangement of the *Hai Tien* and *Hai Chi* consists of four double-ended and four single-ended cylindrical boilers. These are placed in three watertight compartments, two double-ended boilers in the forward and aft compartments, and four single-ended boilers in the midship compartment. There are two funnels, two double-ended and two single-ended boilers being led into each. The forced draft arrangements are on the closed stokehold system, with four fans to each compartment. It will be seen that the boilers of these vessels furnish examples of three of the principal types of warship boilers, viz.: (1) the large-tube water-tube type, represented by the Belleville boiler; (2) the small-tube water-tube type, represented by the Yarrow boiler; (3) the cylindrical fire-tube boiler.

DETAIL CONSTRUCTION.

As to the detail construction of the types under consideration, that of the Belleville boiler has already been fully described in various papers read before the Institution. The economizer type of this boiler is fitted on the *Andromeda*. The tubes, which are of solid-drawn steel galvanized externally, are 4 1-2 in. dia. in the generator elements, and 2 3-4 in. dia. in the economizer elements in the boilers of the *Andromeda*. In the *Hermes* the generator tubes are 4 in. dia., and the economizer tubes 2 3-4 in.

In the boilers of the *Don Carlos* some departures have been made from the usual Yarrow type. The method of manufacture is to completely rivet up the steam drum, the tube holes being previously all drilled through a cast-iron template. The wing pocket tube-plates are also drilled to template, and are then erected together with the steam drum on a triangular frame. The boiler is then tubed in the ordinary way, and the tubes expanded and bell-mouthed, after which the ends and bottom plates of the wing pockets are riveted in place. This completes the part of the boiler subjected to pressure. The tube ends are readily accessible in the finished boiler by means of ordinary manholes in the steam drum and water pockets. These manholes are flanged inward, and fitted with ordinary internal doors. The tubes are of solid-drawn steel, the two rows next the fire being 1 3-8 in. dia., .128 in. thick, and the rest 1 1-8 in. dia., .104 in. thick. It will be noticed that all the tubes are straight, except the two rows next the fire, which are slightly curved. The reason for the adoption of this curvature is that these front rows of tubes, which are subject to higher temperatures and more sudden changes of temperature than the rest of the tube surface, have in some cases, when initially straight, shown a tendency to spring against each other in varying directions. This obstructs the uniform flow of the gases, besides being mechanically objectionable. By slightly curving the outer rows as shown, any springing takes place in a known and definite direction, and does not, therefore, have the effect above indicated, whereas the curvature is so slight that it does not appreciably interfere with cleaning or inspection.

The boilers are fitted with straight external downcomer stay tubes, and, in addition to this, a certain number of tubes at each end of each pocket are baffled off from the fire to insure them working as permanent downcomers, and, as far as possible, maintaining a uniform direction of circulation in the boilers. The tubes are arranged in the tube-plates with several gaps on the fire side. The object of this is to throw a great number of tubes into actual contact with the fire, and thus somewhat relieve the outer rows, which are very severely worked. This arrangement also somewhat increased the combustion space. There are no stay

*Paper read before the Institution of Naval Architects, England.

tubes actually distributed throughout the tubeplate, these not being found necessary, besides being objectionable, owing to their greater thickness, and consequent different expansion to the adjacent tubes. That they are unnecessary is, the writer submits, shown by the following experiments made upon this point:

A tube 1 1-8 in. dia., .104 in. thick, standing 1-8 in. above tubeplate, and merely expanded in, resisted a load of 4.6 tons being drawn out. A similar tube, standing 1-16 in. above, required 4.22 tons, and a third just flush was drawn out by 3.3 tons load.

It will be seen that the strength of a large nest of these tubes is enormous, and is further increased by all the tubes being bell-mouthed inside. This latter operation also has the effect of improving the flow of water into the tubes, and thus assists circulation.

A matter of great importance in boilers of this type is the design of the casing work. These casings have to withstand not only high temperatures, but many sudden changes of temperature. They require to be stiff to maintain their form, but must be arranged to accommodate themselves readily to varying conditions of strain produced by heat, and, above all, they must remain airtight. The form of casing adopted has been found to give no trouble whatever. It is arranged in panels, any one of which can be readily removed for examination or overhaul of the part of the boiler at which it is situate. The form of flange attachment adopted gives great freedom for expansion and contraction, besides stiffening the structure.

As to the cylindrical boilers, these are of the usual form and proportions adopted for vessels of similar type. There is a separate combustion chamber to each furnace. The tubes, which are of lapwelded steel, are 2 1-2 in. dia., and all fitted with the Admiralty cap ferrule in the combustion chamber end.

FEED ARRANGEMENTS.

This is always an important matter, but specially so in water-tube boilers holding comparatively small quantities of water, and it becomes most desirable that the feeding should be automatic. The system adopted in the *Andromeda* is that generally used with Belleville boilers. Two large feed tanks, holding in all 13 tons of water, are placed high up in the engine room. These large tanks are necessary, owing to the variable weight of water in these boilers when working at the different rates of evaporation due to sudden changes of speed of ship. The feed water is taken from the hot-well by special pumps, and is pumped through the filters into the feed tanks. Thence it flows to the boiler feed pumps, and is delivered into the boilers through Belleville feed regulators, which control the speed of the pumps by means of pressure produced by the inlet valves, which are actuated by a float arrangement.

In the case of the *Don Carlos* the feed water is pumped by the air pumps into two vertical feed tanks, each holding 3 1-2 tons of water. Thence it flows by gravity through the feed filters to the feed pumps in the stokeholds, of which there is one to each boiler. The pumps are of duplex type, and are controlled by Mr. Yarrow's special arrangement, the steam supply to the pumps being taken from a guarded pipe just above the normal water level, so that, if the water is high in the boiler, it enters the pump cylinder, and so checks the speed of the pump. The fitting is extremely simple, and worked admirably throughout the trials, and also when steaming at low speeds in the river, etc. It has, however, the objection of being somewhat wasteful, and is barely so sensitive as the arrangements which check the feed supply direct.

The feed system used for the cylindrical boilers is for the air pumps to deliver to a vertical tank in the engine-room, holding 4 3-4 tons of water. From this it flows by gravity to the boiler feed pumps, which are in the stokeholds which deliver through the filters into the boilers, the feed regulation being by hand.

SPACE AND WEIGHT.

On looking at the floor area occupied by the three types of boiler, it will be seen the horse power developed per square foot under natural draft is approximately the same. In other words, that for continuous steaming practically the same power may be obtained from the same size of boiler-room whichever of the three systems is adopted. If, on the other hand, the maximum powers are considered, the advantage of both the Yarrow and cylindrical type is very marked, as by the use of forced draft very much higher powers may be developed for short periods. Again, looking at the heating surface contained in the various boilers per square foot of floor space, it will be seen that the Belleville and cylindrical type, which have about the same amount, have both substantially less than the Yarrow system. This seems to indicate that the loss of economy of the Yarrow type, when moderately forced, will not be very serious, whereas the cylindrical boilers can only be forced at a sacrifice in economy. This is borne out by experience, although at low powers the cylindrical type is more economical.

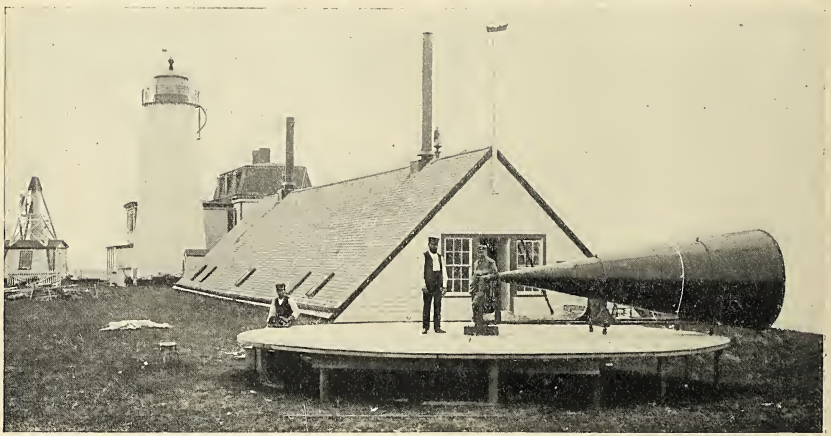
On comparing the grate area per square foot of floor space, the Belleville type possesses a substantial advantage. This is still more evident if comparison be made on the basis of 6 ft. 3 in. firebars, and there is an unquestionable loss of efficiency in stoking longer bars for long consecutive periods. The large grate area on moderate length of bar obtained on a given floor space is one of the strong points of the Belleville type, and makes it an excellent boiler for maintaining high sea speeds for considerable lengths of time. This great gain is partly discounted by the loss of efficiency, if the stoking is indifferent. Owing to the tubes being so close down to the grates, the fires have to be kept very thin but very uniform to insure good combustion. This trouble has been minimized by the introduction of a combustion chamber in the economizer variety of the Belleville type, but it is still a real one, and in evaporative trials a change of stokers may easily affect the evaporation per pound of coal to the extent of 10 per cent. This difficulty is noticeable also in the Yarrow type, but to a less degree, owing to there being much more space for combustion before the gases come in contact with the tube surface.

A recent issue of Lloyd's Register gives the British Empire a total, for last year, of 10,998 vessels of over 100 tons, these vessels having a total tonnage of 13,988,508 tons. The United States is put down as having 3,010 vessels of a total of 2,465,387 tons, which places this country second on the list.

IMPROVED APPARATUS.

Fog Signal Experiments.

How to render navigation safe in thick weather is a question which has engaged the attention of many inventors and experimentalists without any very satisfactory result at the present day. Fog signals there are in great variety, but there are two great uncertainties attending their use, whether whistles, Dabol trumpets or sirens are used. One is the difficulty in locating the source of sound with accuracy, and the other is the zones of silence with which a signal is sometimes surrounded. In sailing toward a fog signal different persons may vary ninety degrees in their estimate of its true direction, and when going away from the sound the difficulties are much increased. There are now in use several instruments, modifications of the megaphone, which are intended to be carried on vessels for the purpose of locating fog signals, be they on ship or shore. All such inventions are intended for the listener, and were there fifty vessels in the vicinity of one fog signal each would have to be provided with an instrument for locating the signal—not a likely condition when the possession of the instruments is optional. It occurred to R. F. Foster, the inventor of the instrument of which we here publish an illustration, that this was working at the wrong end of the problem, and that the proper place to locate a fog signal was in the signal itself, so that if a person heard it at all he could be certain of its direction, without being compelled to use any instrument. On this theory a signal was built and installed at Falkner's Island, in Long Island Sound, under the supervision of the United States Lighthouse Board. The apparatus consists in brief of an immense megaphone, mounted on a circular table. By changing the position of the 'phone toward each of the principal points of the compass in turn, and by blowing a different signal at each point, the compass bearing is given to passing vessels. Experience with the instrument goes to show that the sounds can be confined to an arc which is equal to the angle of the megaphone, and that unless a vessel is directly in the axis of the instrument it can not hear anything at a distance beyond two miles. Within the angle of the instrument a vessel can hear the signal which is sent in that direction even if it is eight or ten miles away. As the vessel approaches within two miles it can faintly hear signals when it is not in the angle of the megaphone, but the signals sent directly toward the vessel are always distinct. By getting its bearings in different points of its course, a vessel may determine, by triangulation, not only the position of the observed signal, but its distance. The apparatus works automatically, a three-horse power gas engine being sufficient to pump all the air required for blowing the signals and to turn the worm gear that revolves the megaphone. The piston of the signal valve works against a ring which controls the long and short blasts, something on the principle of a cam. In the apparatus as arranged for moving vessels this ring is so placed that it can be kept headed to the north, so that the signals are always sent in their proper direction, no matter how much the vessel may change her course. When the megaphone, in the course of its revolution, points directly over the bow of the vessel, a supplementary signal of a different character is blown. This shows the listener the exact angle of the course being steered from the observed position, the megaphone traveling from north to east at the rate of five seconds for each point of the compass. This invention is controlled by the Hamilton-Foster Fog Signal Company, 71 Broadway, N. Y., where a working model of the apparatus can be seen.

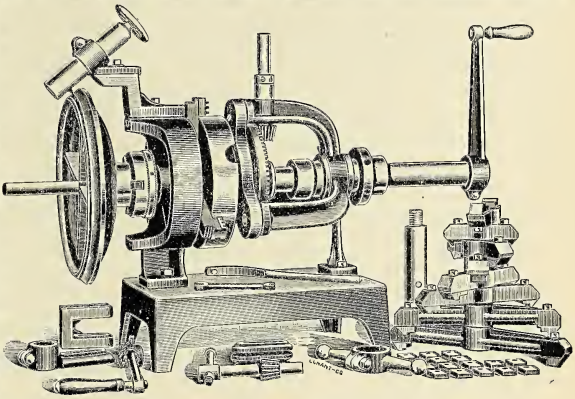


EXPERIMENTAL STATION OF HAMILTON—FOSTER FOG SIGNAL, FALKNER'S ISLAND, CONN.

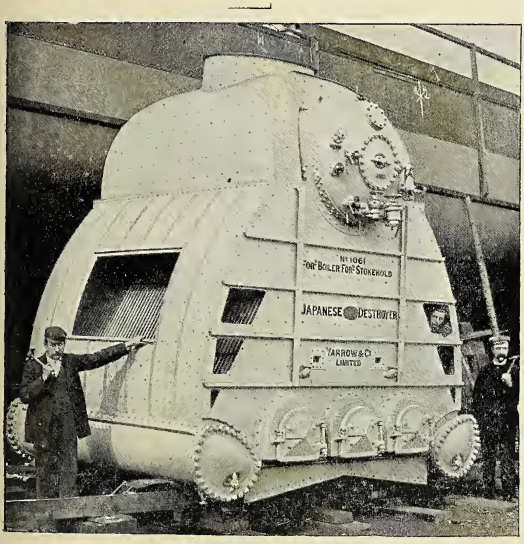
Valve Reseating Machines.

To reseat valves in position is the purpose of the Dexter patent valve reseating machine, which we here illustrate along with the disc cutter attachment. This size machine will work on any size globe valve from 4

in. to 12 in., inclusive, without removing the body of the valve from its connections, and with the disc cutter attachment the valve itself, when it is of the globe type, can be refaced. The disc mounted on a spindle is held in a small chuck, and to this is given a rotary motion by turning the crank on the spindle of the machine. The tool is held rigid and is gradually fed over the contract surface of the valve. Disc valves with flat faces can also be turned true by the use of another attachment which is provided. The advantages of the apparatus in respect to speed, accuracy and convenience, when compared with the use of the hand scraper and abrasive substance for grinding in need not be more than mentioned. The apparatus has been in use in the United States navy for a considerable time, among the ships so supplied being the battleships *Oregon, Iowa* and *Massachussetts*, and the armored cruisers *Brooklyn* and *New York*. A variety of other reseating machines on the same principle for all sizes of valves, and for special uses, are made by the manufacturers, the Leavitt Machine Co., Orange, Mass. Special care is taken with the cutters of these machines, which are also protected by patents. The cutters for the smaller valves are made of round steel and those for the larger sizes of flat bars. They operate with a shearing cut, producing a perfectly smooth surface.



DEXTER VALVE RESEATING MACHINE.



YARROW EXPRESS WATER TUBE BOILER.

Yarrow Express Boilers.

Our engraving shows one of the four Yarrow boilers fitted in the Japanese destroyer *Akebono*, which recently attained a speed of 31.15 knots on trial. This boat is one of six destroyers ordered from Yarrow by the Japanese Government, each vessel measuring: Length, 220 ft.; beam, 20 ft. 6 in., and having twin screw engines, with cylinders 20 1-2 in., 31 1-2 in. and two 34 in. dia. and 18 in. stroke. The boilers are built for a working pressure of 230 lbs. per sq. in., and are the largest of their type yet constructed. With water and fittings each weighs 18 tons. The capacity of each boiler is figured at 1,600 horse power. This type of boiler is fitted with straight tubes, which can be easily examined internally and cleaned out readily. On the trial of the destroyer, with 1 1-2 in. air pressure in the stokehold, a pressure of 226 lbs. was maintained on the boilers, the engines turning up to 439 1-2 revolutions. We are informed that there was no flame visible at the funnels and the paint on them "was very little darker on the return of the boat than when she started." These boilers were designed and built by Yarrow & Co., Ltd., Isle of Dogs, Poplar, London, E., England. This type of boilers has also been fitted in large war vessels.

The Hamburg-American Co. has made a new departure by ordering from a German yard a 400 ft. steam yacht which is to be fitted out for the carriage of first-class passengers, only, and the necessary stores and coal, the intention being not to carry any cargo. The new vessel is to be named the *Princess Louise Victoria*, and in the season she will make trips to Norway, the Mediterranean and the Orient.

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Copy for changes in advertisements must be in our hands not later than the 20th of the month to insure changes being made in the issue of the month following, and not later than the 15th of the month if corrected proof is to be submitted.

We desire to call the attention of our subscribers to the changed address of this publication from the World Building to 309 Broadway, New York. It is naturally with reluctance that a publication removes from a location with which it has become more or less identified, but in the present instance the change was compelled by the rapid and continuous growth of the undertaking. Once before, since the commencement of publication, early in 1897, a removal was made necessary for the same reason. On that occasion enlarged quarters in the same building temporarily sufficed. Now however, the activities and business of this paper are such that we have been compelled to occupy a very largely increased amount of space. To those of our friends who have visited us at our former office, and to those whom we have not as yet had the privilege of greeting in person, we extend a cordial welcome to the new home of Marine Engineering.

ALDRICH & DONALDSON.

ANOTHER series of races for the *America's* Cup has been concluded, with the usual result—the cup stays on this side. Now that the races are over, and with America rests the victory, we feel at liberty to discuss certain features connected with the contest. As a cup defending and a cup "lifting"—to use the idiom of the challenger—match it was without question a remarkably well conducted affair. As an international competition between sport loving yachtsmen, pure and simple, its success, we believe, can be seriously questioned. It is well to recall the origin of these cup races. In August, 1851, the yacht *America* entered a race in British waters, around the Isle of Wight, and won easily by eighteen minutes. There was no press agency accompaniment to the entry of the American boat, whose owner in a thoroughly sportsmanlike fashion sailed in, won the race and the cup, and took it home. His boat was a cruiser built for yachting, not cup lifting, and was a good representative of the American type. Forty years later the cup is challenged for by a gentleman, who, according to his own statement, does not know how to sail a yacht; and the yachts themselves are such in name only. In reality they are huge racing machines, built at enormous expense, and necessitating the employment of large crews; and they are adapted only for the special purpose of sailing for the Cup or in other similar contests. On the part of the last challenger entire dependence was placed on the professional services of those in his employ to win the cup; and this, by contrast, actually caused severe criticism of the presence of amateurs on board the *Columbia*. Under the conditions there may have been some grounds for criticism, but it is certainly a peculiar state of affairs when the presence of the owner and his fellow clubmen on board one of the yachts calls for censure. As a matter of fact, the international cup races have become not at all so much a contest between amateur yachtsmen as a matter of engineering construction—the pitting of the skill of one designer here against that of a designer abroad. In the sailing of the boats there is little to choose from; wind and tide are identical for both, and the whole contest practically narrows down to one of design, and, of course, construction. In this may be properly included the propelling mechanism—sails. In the recent race the British boat (not Irish, as some would have us believe) had a marked advantage in this respect, and so the more plainly is shown the superiority of the American design of hull. In the matter of sails there is, indeed, a distinct retrogression on our side in the forty odd years. When the *America* sailed her winning race the features of all others that attracted attention and praise was the set of her sails. Even the conservative and authoritative London *Times*, after the race, referring to the *America*, admitted: "The way her sails were set evinced a superiority in the cutting which our makers would barely allow; but certain it is that while the jibs and mainsails of her antagonists were 'bellied out' her canvas was as

flat as a sheet of paper." Conducted with a view to promote yachting interests at large, instead of merely cup lifting or defending, the value of these contests would be immeasurably greater than now. Bringing down the maximum size of boat allowed to ordinary dimensions would be the first step toward this end. The immediate result would be, that the expense of an effort to lift or defend the cup would come within the means of many who are yachtsmen rather than capitalists. A variety of designs would be put forward, representing the skill of many designers, and in this way scientific effort would be aided by wide experience with various types. Yacht building and racing would be greatly stimulated. It would then be a possibility with many to win in the trying out process, and eventually in the race itself. Instead of a concentration of interest on one series of races, there would be a healthy competition among local sportsmen at various centers, and the event would be truly representative of the sport as conducted in the competing countries. No doubt a rearrangement of the governing conditions would be needed—a matter presenting no insuperable difficulties.

IN his masterly paper read before the British Association—the publication of which we begin in other pages in this issue—Sir William White, Constructor-in-Chief of the British Navy, refers at some length to the value of model experiments, and after touching upon the work done at various government naval experimental stations, states very plainly his opinion of the future possibilities of such research in these words:

> In this direction, however, I am bound to say that much might be done if experimental establishments capable of dealing with questions of a general nature relating to resistance and propulsion were added to the equipment of some of our universities and colleges. Engineering laboratories have been multiplied, but there is as yet no example of a model experimental tank devoted to instruction and research.

In connection with these remarks it should not be forgotten that at Cornell University, an institution which has always held first rank in its technical equipment, a start has been made which we hope may soon result in the establishment of a plant for experimental research, such as Sir William White refers to—a plant suitable for research in all those branches of hydromechanics which are of such vital importance to the naval architect and marine engineer. It may be recalled that an extensive hydraulic laboratory has recently been installed at this institution, one feature of which is a canal or tank suitable for experiments in this field of investigation, whose importance has recently been recognized by the government in the installation of the magnificent equipment at the United States Navy Yard, Washington, D. C. While the canal at Cornell is but 340 ft. in length by 16 ft. wide and 10 ft. deep, and, therefore, smaller than the government tank at Washington, it is nevertheless of quite sufficient size for work of a most valuable character, and we may be sure that in due time, when the needed equipment shall have been provided, the Cornell tank may be confidently looked to for most valuable additions to our existing knowledge in these subjects. It is understood that at the present time funds are lacking for the immediate equipment of the canal with the necessary apparatus, and due to this fact alone the inauguration of important investigation is for the moment delayed. Here is an opportunity for those interested in marine construction to forward its interests in a most direct and valuable way. The opportunities here are so great that any further delay by reason of a lack of equipment is most seriously to be regretted, and we may be permitted to hope that in the immediate future ways will be found of providing the needed funds and of installing the necessary apparatus. The opportunities of an experimental establishment thus installed under educational auspices alone will be quite exceptional and unique. It will be unhampered by commercial restrictions, or by rivalries, either commercial or naval. The information obtained, instead of being deposited in a safety vault as has hitherto been the case, at least in all the European establishments, will be given freely for the benefit of all who may be interested. In these days of sharp commercial rivalry it is safe to say that other things equal, the shipyard which combines a thoroughly up-to-date equipment and a practical ship and engine building staff, with a scientific staff capable of taking every advantage of the facts which experience and special investigation may furnish, will take the lead. The significance of an experimental establishment thus free to investigate any and all subjects of scientific interest, and equally free to give forth the results for the benefit of those who may choose to profit by them, is clearly seen from this point of view. The opportunities of Cornell University in this field are, therefore, at present quite unique, and of an importance hard to overestimate. Let us hope that she will be able to realize the expectations which we may justly form.

MARINE BREAKDOWNS AND LOSSES.

LOSSES OF THE BRITISH STEAMSHIPS SCOTSMAN AND BAY STATE.

Many serious marine losses, both home and foreign, occurred during the past few weeks. Late in September the new Dominion liner *Scotsman*, bound west from Liverpool to Montreal, went ashore in the Straits of Belle Isle, and will probably be a total loss. She had a large passenger list and valuable cargo. Several lives were lost, due chiefly to the ruffianism of the crew, which is reported to have been composed of the scum of the Liverpool docks, shipped to replace the regular seamen who were on strike when the vessel sailed. The weather was bitterly cold when the mishap occurred, and those of the passengers who got ashore safely had to spend several days and nights on the bare rocks, scantily clothed and with little or no food to eat. The only habitation near was the Belle Isle light, five miles distant in a direct line, but much further by the only road, which led through almost impassable country. Signals for help were made from the lighthouse at intervals, but not until the fifth day after the mishap did assistance arrive in the shape of the Elder Dempster steamship *Montfort*, which was passing. Many of the passengers were transferred to this vessel, and subsequently aid reached those who were left behind. According to the statement of cabin passengers who finally reached New York the crew broke loose after the vessel struck and laid violent hands on passengers who had valuables, also breaking into the cabins and liquor stores of the vessel. Many of the crew who got away were arrested at Canadian and British ports. Captain Skrimshire of the *Scotsman* is reported to have laid the blame for the mishap on the Canadian authorities, who recently removed an explosive fog signal at Belle Isle and substituted for it a siren, notice of which had been published.

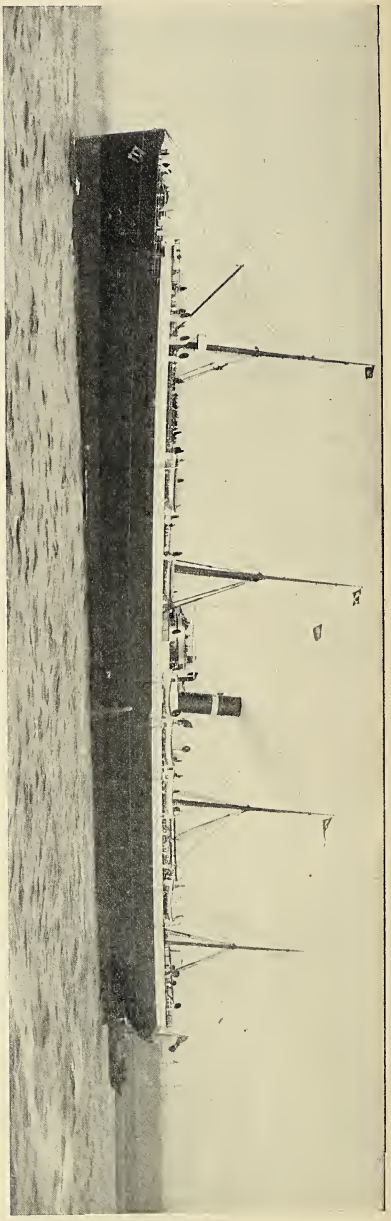
The *Scotsman* was only about four years old, and was a good product of the Harland & Wolff works of Belfast, Ireland. Her dimensions are as follows: Length, 470 ft., beam, 49 ft., and depth, 31 ft. Her gross tonnage is 6,041 tons. Her engines are triple expansion, driving twin screws, and she is fitted with four pole masts.

The Warren liner *Bay State*, from Liverpool to Boston, went ashore in a dense fog in Chance Cove, about sixteen miles from Cape Race, on October 3, and became a total loss. Her crew took to the boats and were picked up at sea.

Rear-Admiral George W. Melville, Engineer-in-Chief, U.S.N., has been elected an honorary member of the Franklin Institute of Philadelphia, Pa.

Japan is gradually increasing her shipbuilding facilities. There is now under construction at Nagasaki a steamship of 6,000 tons.

John Donaldson, a member of the firm of famous torpedo boat builders, Thornycroft, at Chiswick, London, died recently, aged 58 years. Mr. Donaldson was widely known as an engineer and as an advocate of the torpedo boat.



Photograph by Priestley Sons, Ltd., Liverpool, England.

DOMINION LINER SCOTSMAN IN SERVICE BETWEEN MONTREAL AND LIVERPOOL—LOST IN THE STRAITS OF BELLE ISLE RECENTLY—6,041 TONS GROSS.

EDUCATIONAL DEPARTMENT.

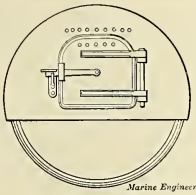
HELPS FOR CANDIDATES FOR MARINE ENGINEERS' LICENSES—BOILERS—II.

BY DR. WILLIAM FREDERICK DURAND.

§ 2 MATERIALS AND CONSTRUCTION.

[3] CONSTRUCTION OF FIRE TUBE BOILERS—*Continued.*

Furnace Fronts and Doors.—The furnace front is a fitting attached to the mouth of the furnace, and carrying the furnace door. In Fig. 1 a common form of arrangement is shown. The front consists of a cast iron shell forming the outer part, and made with lugs or a flange for attachment to the furnace. The opening for the door is formed, as shown, within this front or door frame as it is sometimes called. Attached to this frame and with a space between is a plate of cast or wrought iron forming the inner wall. This is pierced with a large number of small holes, while the frame is provided with a smaller number of larger holes. These are provided for the purpose of admitting air to the furnace above the grate. The inner plate is subject to the direct action of the fire, and although cooled somewhat by the air passing through, it is liable to burn out from

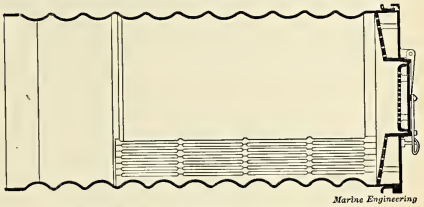


FURNACE FRONT.—FIG. 1.

time to time. It is for this reason that it is made as a separate piece, and so is readily replaced as occasion requires. The door is formed in much the same way as the frame, and is provided with holes in a similar fashion and for the same purpose. Often a small covered peep-hole is provided for examining the fire without opening the door. In some cases also a small opening is made through which a slice bar may be introduced for stirring or breaking up the fire without opening the door. A form of slide or gridiron is also sometimes fitted so as to control the amount of air entering above the grates. In some cases the doors and frames are made of flanged steel plate instead of cast iron, while much variety exists in the arrangement of the holes for the introduction of the air. Certain special fittings necessary to adapt the furnace fronts and doors to the application of forced draft will be described at a later point.

The ash-pit door usually consists simply of a plate of thin sheet steel provided with the necessary lugs and handles, and covering the front opening in the furnace below the grate bars. It is used chiefly as a damper in connection with closed stokehold forced draft.

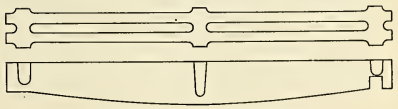
Grate and Bridge Walls.—The general arrangement of the inside of the furnace is illustrated in Fig. 2, which shows a horizontal section through a furnace. The grate extends from the front of the furnace to the bridge wall. See Fig. 4. The bottom of the door frame extends back a little way and drops down, forming a kind of shelf for the support of the front ends of the grate bars. In some cases this extension of the door frame extends back some distance, forming the so-called *dead plate*, upon which bituminous coal may be piled when first



HORIZONTAL SECTION OF FURNACE.—FIG. 2.

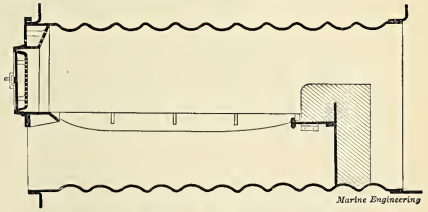
fired, so as to provide for the gradual distillation and combustion of its gases.

The grate bars may be made in a large variety of forms. In Fig. 3 is shown the standard type of cast iron bar. There are two lengths of bar in the length of the furnace, supported by the door frame in front and bridge wall at the rear, and by *bearing bars* in the middle. These latter in turn are supported at their ends by attachment to the furnace. The bars are usu-



CAST IRON GRATE BARS.—FIG. 3.

ally cast double, as shown, while for convenience in fitting grates of varying widths, a small number of single bars are usually provided. The width of air space between the bars is usually made about equal to the width of the bar, or about one-half of the entire grate area. One end of the bar is made sloping as in the figure, in order to provide for expansion. The surface of the grate usually slopes slightly from front to rear, from 1



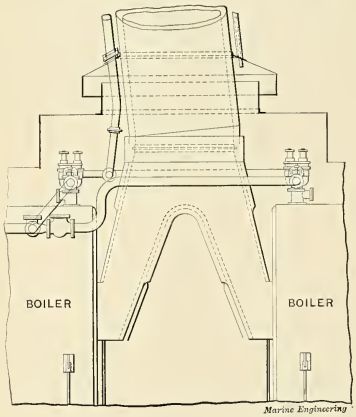
VERTICAL SECTION OF FURNACE.—FIG. 4.

in 24 to 1 in 12, covering the usual range of angle. It is doubtful if there is any necessity for this slope, which was probably introduced as a provision against the sliding of the fire to the front in heavy weather. Cast iron grate bars often have a shallow groove running along the top. This fills with ashes and tends to prevent the clinkers adhering to the grate.

In addition to the type of bar shown in Fig. 3, square wrought iron bars running the whole length of the furnace are sometimes used, and there is a large variety of patent and special kinds of shaking grate. The purpose in grates of this character is to provide means for breaking up and working the fire without the need of opening the door. Many of them accomplish this end to a considerable extent, but the greater simplicity and cheapness of the plain cast iron grate, as in Fig. 3, insures for the latter a wide use, and it is still the favorite in ordinary practice.

Turning now to the bridge wall, a common arrangement is shown in Fig. 4. A casting extends across the back of the furnace and is supported by attachment at the sides. This supports the back ends of the grate bars, as already referred to, and also a wall of fire brick which forms the back limit of the grate, and over which the products of combustion pass on their way to the combustion chamber.

Instead of fire-brick, the use of cast iron for bridges is becoming frequent in modern advanced practice. Such bridges are of ribbed or channeled form, and in use they become sufficiently covered with ashes to form a protection against the heat of the fire.



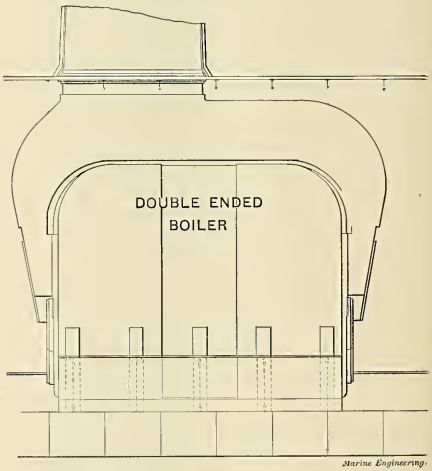


FIG. 5. FRONT CONNECTIONS, UPTAKES AND FUNNELS. FIG. 6.

Front Connections and Funnel.—After leaving the tubes at the front end the gases and smoke must be guided to the base of the funnel. This is done by the front connections or smoke boxes and uptakes, as shown in the sketches. Fig. 5 shows the connection made between two single ended boilers and one funnel, used in common by both. The boilers are placed front to front in an athwartship fire room. Fig. 6 shows the connections between one double ended boiler and the smoke pipe. These connections are formed of sheet metal riveted up in two or more thicknesses with an air space or non-conducting material between. The term *front connection* refers more especially to that part of the passage directly in front of the tubes. This is provided with doors swinging upward to allow examination, cleaning and repair of the tubes. A swinging damper is often placed in the uptakes for controlling the draft as may be desired, especially where two or more boilers are connected to one stack. The funnel or stack is also made of sheet metal riveted up, and in good practice in two thicknesses with a considerable air space between. This tends to prevent loss of heat by radiation, and thus the temperature of the gases is kept as high as possible while in the funnel, as is necessary for good draft. It may be remembered that for boiler economy the temperature of the waste gases at the front connection should be as low as possible, while for the sake of the draft all further loss of heat while in the funnel should be prevented. Around the base of the funnel is fitted an additional air screen or passage, known as the *air casing*. See Fig. 7. This serves to ventilate the fire-rooms and to protect the neighboring parts of the ship from the heat radiated by the funnel. The air casing is protected from the weather by a sloping ring of metal attached to the funnel, as shown in Fig. 7, and known as the *umbrella*.

The weight of the funnel is usually carried by straps or lugs attached to the structure of the ship, and it is furthermore stayed by guys on deck in order to provide the necessary steadiness and support in a sea-way. In small craft, however, the weight of the funnel is often taken simply by the uptakes and boilers.

The funnel is often provided with a cover which may be placed over the top when the ship is laid up, or when for other reason the funnel is not in use. The cover is usually kept a little distance above the top so as to allow the escape of smoke from small fires used for warming and airing the boilers. A ladderway should also be provided on the funnel to assist in examination, adjustment of guys, fitting of cover, etc. In small craft a damper is often fitted in the funnel near the base, to assist in controlling the draft.

CONSTRUCTION OF WATER-TUBE BOILERS.

Only a few points will require special notice under this heading. We have already seen that many types of water-tube boiler consist of one or more cylindrical drums above and one or more below, joined by a series of tubes. See MARINE ENGINEERING for July, Figs. 5-9. These drums, which are rarely more than 18 to 24 in. dia., are made from steel plates usually by flanging and riveting in the usual manner. The heads alone of such drums require consideration as regards bracing. If of sufficient size to require it they may be braced by through bolts as with boiler heads. In most cases, however, the heads are bumped or made of dished form, either concave or convex on the outside. The latter is preferable, as the pressure is then carried on the concave side, and according to the United States law such heads are allowed without bracing a pressure the same

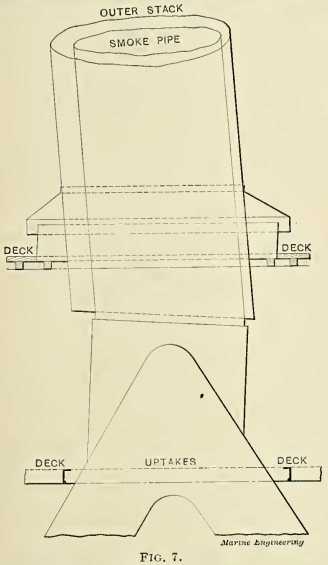


FIG. 7.

as that for a cylindrical shell of a diameter equal to the radius of the sphere of which the head forms a part.

It is much preferable to form the heads in this way, avoiding the need of bracing, and thus leaving the interior of the drum free for examination, at least so far as bracing is concerned. To allow access to the interior, manholes or hand-holes with appropriate cover plates are fitted to the heads. Instead of forming these drums with riveted joints, drums with welded joints have recently come somewhat into use, especially in naval practice.

With boilers having headers formed by the space between two parallel sheets, the necessary arrangements are quite different. These sheets require special support, and this is usually provided by screw stay-bolts or other equivalent stays worked between the two sheets attached to the tube sheet between the tubes as convenient, and securely tying the two sheets together. In some cases the outer sheets are supported by rod stays passing from head to head through the tubes. In such case the tube sheets are left to be supported by the tubes which are thus thrown into compression, and the tubes must therefore be carefully expanded, especially on the inner side of the sheet, in order to give sufficient hold to support the sheets in this direction.

The tubes of water-tube boilers are of wrought iron or steel, and welded or solid drawn. For the bent-tube boilers solid drawn steel tubes are to be preferred. For straight tube boilers welded iron tubes are still in common use. The tubes are secured to the tube sheets either by expanding or by special fittings with screwed joints. In general there is a force tending to draw the tubes out of the tube sheet or junction box or other form of header, equal for each tube to its cross-sectional area multiplied by the steam pressure. This force must be resisted by the tube fastening, and while it is not usually serious in amount, its existence should not be forgotten, and the need of care in the fastening is shown.

The furnaces of water-tube boilers are formed of grate-bars with a space below for ash-pit, all inclosed in the same general casing which surrounds the boiler as a whole, and as shown in the various figures referred to in the foregoing.

Often a considerable amount of fire-brick is used as a lining to the furnace, and for protection to the lower ends of the tubes.

Due to the great variety of forms of water-tube boilers, the details of construction often present the widest variation, and they cannot be so readily reduced to standard forms as in boilers of the fire-tube type.

ELECTRICITY ON BOARD SHIP—PRINCIPLES AND PRACTICE—XX.

BY WM. BAXTER, JR.

METHODS OF DISTRIBUTION.

There are two methods of electrical distribution, one of which is called the "series," and the other the "parallel." The first is also called the constant current system, and the second the constant potential system. Fig. 115 illustrates the series, or constant current system, and Fig. 116 the constant potential system. In Fig. 115 G represents the generator, and L the circuit,

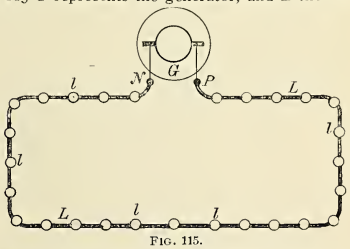


FIG. 115.

the lamps, motors or other devices operated by the current being represented by l l. That this system must be operated by a constant current can be readily understood, for suppose that some of the lamps required a current of ten amperes while others required fifteen, then, since the current flowing in the circuit must be of only one strength, it is evident that if it is ten am-

peres, it will suit the lamps that are designed to operate with that current, but it will not be strong enough for the others. Thus we see that if the devices operated in a series circuit are not all proportioned so as to re-

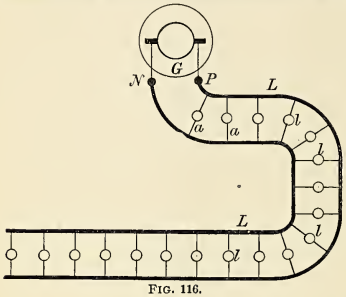


FIG. 116.

quire the same current strength, they will not work properly. The series system is not used on board ship, and in fact its only practical application on an extensive scale is for "arc" lighting. The electromotive force required for series systems is very high compared with the constant potential system, for the voltage must be sufficient to equal that of all the lamps added together; thus if there are fifty lamps, and each one requires fifty volts, the total E. M. F. of the current will be 2,500 volts, plus that necessary to overcome the resistance of the circuit wires. Making an allowance of 10 per cent for this we would have 2,750 volts as the total voltage that the generator would have to develop at the terminals *N* and *P*.

In the constant potential diagram, Fig. 116, *G* is the generator and *LL* are the main distributing lines. These start from the generator terminals *P* and *N*. The circles *l l l* represent incandescent lamps, which, as can be plainly seen, are connected by wires that run across from one of the mains to the other. With this system satisfactory results cannot be obtained unless all the lamps are designed to operate with the same voltage; for, as can be readily understood, the generator can only develop one pressure at the terminals *N P*, that is at any given instant, hence, apparatus that is constructed to work with this pressure will operate properly, but if there are other devices that are designed for some other pressure, they will not give satisfactory results. Suppose there are lamps connected between the mains *LL*, some of which are intended for a 50 volt circuit, and others for 100 volt, then if the actual pressure between the terminals *N* and *P* is 50, the first named lamps will give the proper light, but the others will not. When a beginner first looks at a diagram such as Fig. 116, he concludes that the first lamp *l*, being so much nearer to the generator than the last one, should take nearly all the current and leave the other lamps unprovided for. This, however, is not the result in practice, although it would be, if the relation between the resistance of the several parts of the circuit were as the beginner assumes it to be; in other words, the beginners' reasoning is correct, but he does not understand the conditions correctly. If every inch of length of the mains *LL* and the wires connecting with the lamps *l* and of the lamps themselves offered the same amount of resistance to the passage of the current, then more than half of the total current would pass through the first lamp, if the lengths of the wires were as drawn, and the remainder would nearly all go through the second one, leaving but a trifle for the third, and the next to nothing for the fourth. The resistance offered to the passage of the current by the main lines *LL*, the smaller wires connecting with the lamps, and the latter is very far from being the same; in fact the resistance of the lamps is almost infinitely greater than that of the wire, inch for inch, so that, although there may be several hundred feet of wire, its total resistance is not over 4 or 5 per cent of that of the

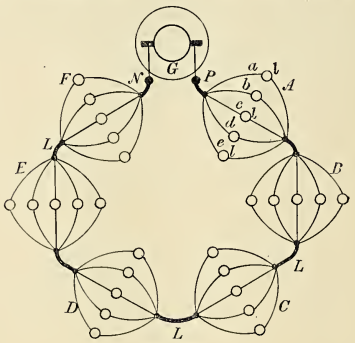


FIG. 117.

lamps. If we assume that the mains *LL* and the wires connecting these with the lamps offer no resistance whatever to the passage of the current, then we can see that the lamp the furthest from the generator will receive just as much current as the one nearest to it, for if the current can flow to either one without any hindrance whatever, it will flow to both in equal amounts. Now in practice it is not possible to obtain a conductor without resistance, although a large copper wire comes very near to it, so near that it requires accurate instruments to measure the resistance of a short piece. By making the mains *LL* of large wire and constructing the lamps so as to have a very high resistance, we approach very nearly to the conditions just explained, that is, of having a circuit without resistance. As will be shown later we can easily calculate the size the wires should be so that the current that will pass through the last lamp will be sufficient to give the proper illumination. It must be remembered, however, that the first conclusion of the beginner is correct, and that the first lamp takes more current than any of those that follow it, but the difference is very slight, in fact the last lamp will be traversed by a current not more than 5 per cent less than that passing through the first one, and the reason why the difference is so small is that the resistance of the wires is practically nothing in comparison with that of the lamps.

The series and the parallel are the two principal systems of distribution, but there are modifications of both that sometimes are convenient; one is shown in Fig.

117, and the other in Fig. 118. The first is called the series parallel, and the second the parallel series. The first can be used in connection with a constant current system, where the strength of the current is more than the apparatus requires; thus if the current is ten amperes, and we have lamps designed for only two amperes, we can arrange them as in Fig. 117 with five in parallel in each group. The arrangement of Fig. 118 is used where the voltage is greater than the lamps require, and is applicable to a constant potential system. Suppose we have a generator that develops a pressure of 250 volts, and that the lamps we desire to use are designed for 50 volts, then by stringing them five in series, as in the figure, we will be able to operate them successfully for 5 times 50 is 250. This last system finds application on board ship in cases where the voltage of the generators is about 100, and there are 50 volt lamps on hand, but none of 100 volts. It is not advisable to follow this construction for permanent work, and no one would do it if possessed of good judgment. For temporary jobs, however, it is often convenient, specially when the electrician is compelled to get along with what is available, and this is a common occurrence when the ship is away from port.

Fig. 116 shows the parallel system of distribution in its simple form. In practice such simplicity is seldom

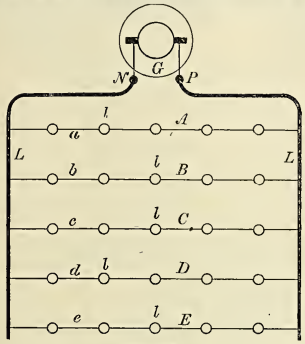


FIG. 118.

obtainable, or desirable. As a rule it is necessary to run out numerous branch circuits, and this is done in the manner shown in Fig. 119, in which the main lines running from the generator terminals are marked *LL*. In actual practice, these lines would run from the switchboard, but we have here shown them running from the generator so as to indicate more clearly the relation between the distributing circuits and the generator. From the main line branches can be run in either direction as shown at top and bottom of the figure, or only to one side as in the intermediate branches. Where the branch circuits are taken off, it is customary to provide distributing boxes, or panels as they are called, and these are provided with switches by means of which the current may be turned on or off as desired, so that all the lights supplied by any branch circuit may be controlled from a single point when necessary. When the lamps are in accessible positions, they are provided with a suitable switch so that each one may be turned off or on independently of the others.

If the boat is made of iron the skin can be used as the return circuit, just as the ground is used in some instances where small buildings are provided with a lighting plant. The practice, however, is not a good one and has nothing to recommend it but economy, and in any first class installation, the circuit wires should be independent of the ship and thoroughly insulated, particularly where there is any danger of making contact with the iron work. River boats, and even those engaged in near-by coasting service, are generally equipped with the same type of lamps and fittings as are used on shore, but sea going vessels should be provided with marine fittings, which are made with a view to withstand the effect of water and moisture. Incandescent lamps having the mountings secured by plaster of paris are not suited to marine work unless the plaster is covered with varnish, or is otherwise treated so as to make it moisture proof. Switches, fuses, junction boxes, etc., should be of the water tight type. Lamps situated in exposed places should be protected against injury, and this is also true of portable lamps. Lamps are constructed in a variety of designs specially for marine work, a number of which are shown in Figs. 120 to 133, which we are able to present through the courtesy of the General Electric Co.

Fig. 120 is the typical marine incandescent lamp, and is constructed so as to withstand the effects of moisture. Fig. 121 shows the way in which lamps that are designed to project downward from the ceiling are protected. Fig. 122 is a similarly protected side light adapted to narrow passages, or in freight compartments, where liable to be broken if not shielded. Fig. 123 shows a type of lamp provided with a steam tight protecting globe suited to boiler and engine rooms, etc.

Figs. 124 and 125 show designs of portable lamps. These lamps are not portable in the fullest sense, for

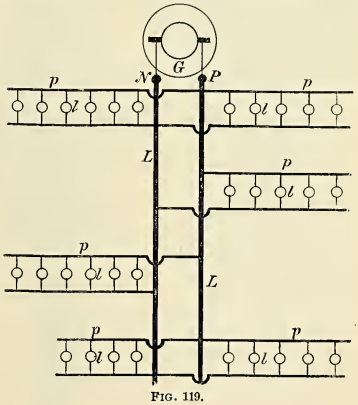


FIG. 119.

they can only be moved around as much as the length of the cable that carries the current will permit. They are generally used to inspect freight, or portions of the vessel not otherwise lighted. The end of the cable is

provided with a plug, that fits into a receptacle shown in Fig. 126. These receptacles can be located at as many points as desired, and by inserting the plug end

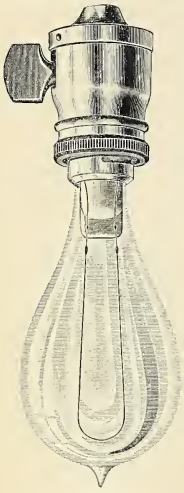


Fig. 120.

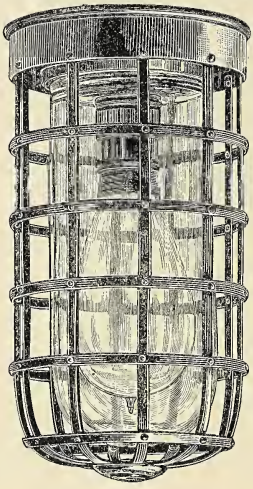


Fig. 121.

of the cable into the hole and turning the switch handle, a light is obtained. For engine repairs or examination of working parts portable lamps are a great convenience.

Fig. 127 is an ornamental ceiling fixture in which the

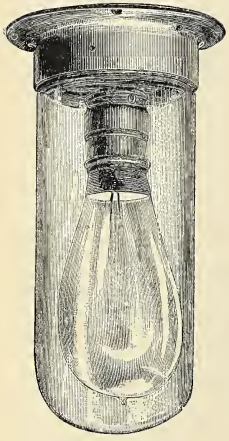


Fig. 123.

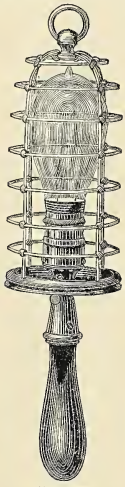


Fig. 124.

lamp is entirely inclosed. Fig. 128 is another design of ceiling fixture, and Fig. 129 is a side bracket lamp. As will be noticed, a characteristic feature of Figs. 127 to 129 is that they are substantially constructed, much more so than would be necessary for land work.

In Figs. 130 to 133 a lantern signaling system is

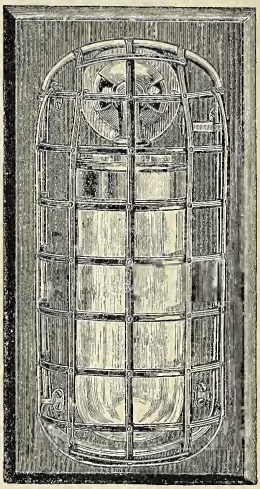


Fig. 122.

shown together with the lantern, the signaling switch box and the cable with its coupling. The lanterns are colored, and each one is provided with two lenses, one white and one red. There are five lanterns, and all of them are connected with the switch box Fig. 132. By the movement of the handle of this switch, the light of any lantern may be made red or white. Sixty-two different combinations of the lights can be made. Fig. 130 shows the lanterns in position in the rigging. Fig. 131 shows one of the lanterns and a portion of the cable, and Figs. 132, 133 illustrate the manner in which

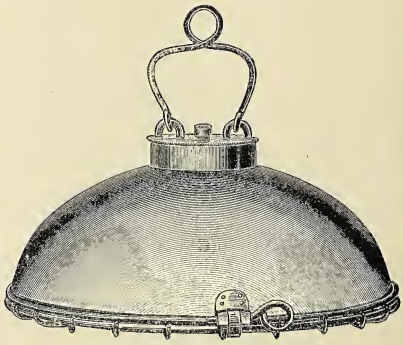


Fig. 125.

the connections between the terminals of the wires in the different sections of cable are made by the couplings.

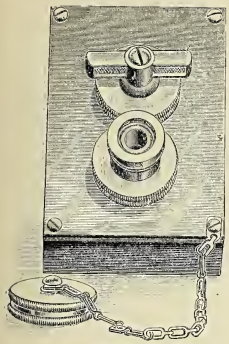


FIG. 126.

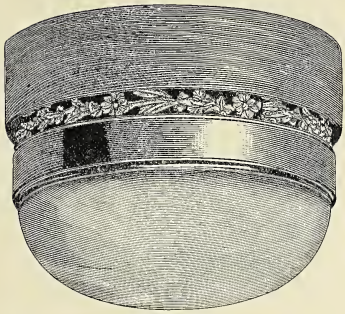


FIG. 127.

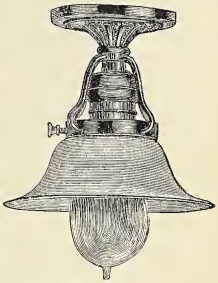


FIG. 128.

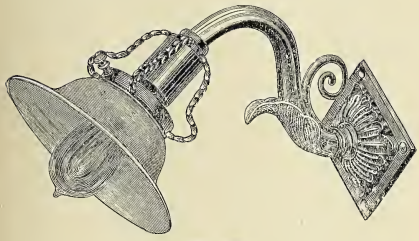


FIG. 129.

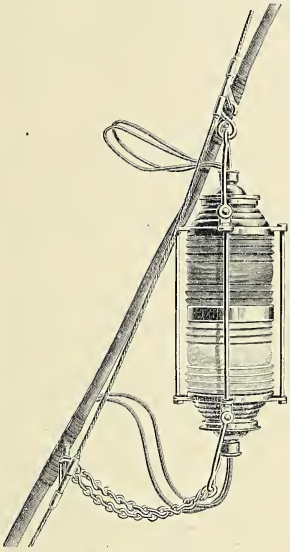


FIG. 131.

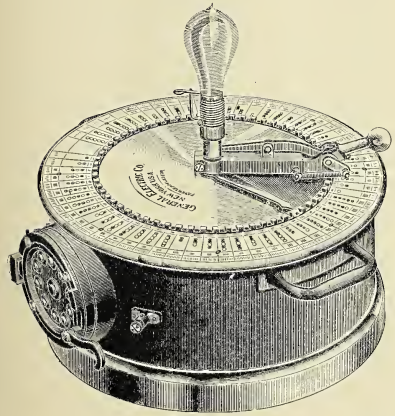


FIG. 132.

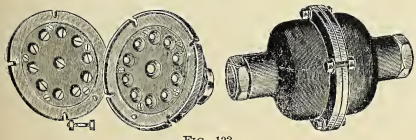


FIG. 133.

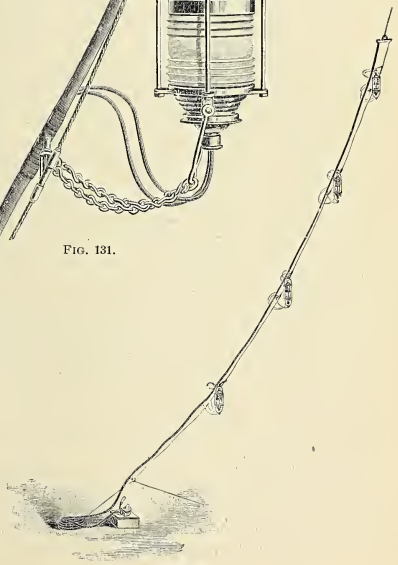


FIG. 130.

ENGINEERS' DICTIONARY.—XXI.

Guide or **Cross-Head-Guide**—A surface either formed on the columns or on a plate of metal carried by them, and serving to support the cross-head in its motion back and forth, and to take the transverse thrust to which it is subject. See under cross-head and column, Figs. 39 and 31.

Gusset-Plate or **Stay**—A form of boiler stay sometimes used for connecting together two plates at right angles to each other, as for example a boiler head to the shell. It consists of a plate of metal joined by angle irons and rivets to the two plates to be connected. See Fig. 9.

Hand-hole—A small oval shaped hole in a boiler shell for purposes of examination and cleaning. It is closed from the inside by a plate or cover with a flanged or lipped edge forming with sheet packing a joint on the inner edge of the metal about the hole.

Hand-Pump, Hand Reversing Gear, etc—The word *hand* as a prefix to the names of various mechanisms or appliances is commonly used to denote such forms as are or may be operated by hand, or without the direct use of power.

Hauled Fires—See under *Fires.*

Heater—See under *Feed Heater.*

Heating Surface—That part of the boiler through which the heat passes from the hot gas to the water. Any part of the boiler which is exposed to hot gas on one side and is in contact with water on the other may be considered as heating surface. It consists chiefly of the surface of the tubes, combustion-chambers and furnaces. See also under *Boiler.*

High-Pressure Boiler—A boiler specially intended for high pressures. During the period of change from the early types of marine boiler of more or less rectangular section and suited only for very low pressures to those of more modern form and suited for higher pressures, this term was often used in referring to any boiler of cylindrical form.

High-Pressure Cylinder—In a compound, triple or quadruple expansion engine the smallest cylinder, or that into which the steam enters first. See under *Engine.*

High-Pressure Engine—The high pressure cylinder, with its columns and the moving parts, sometimes referred to as the *high-pressure-engine.* The term is also sometimes used in referring to a *non-condensing* engine. See under *Engine.*

Holding-Down Bolts—The bolts which secure the engine bed-plate to the engine seating or foundation. See under *Engine.*

Horizontal Cylinder or Engine—A cylinder whose axis is horizontal, or an engine in which the moving parts move in a horizontal rather than in a vertical or oblique line. See under *Engine.*

Horse-Power—*Power* is the capacity to do work, and it is measured by the amount of work done in a given time. The unit of measurement used by engineers is the *horse-power* which is defined as 33,000 foot-pounds of work per minute, or 550 foot-pounds of work per second. To find the horse-power in any given problem, we must therefore find the number of foot pounds of work done per minute, and divide this by 33,000. To find the foot-pounds of work we must remember that work is measured by the product of a force by the distance through which it acts, and the common unit is the force of one pound acting through the distance of one foot, and is called a *foot-pound.* Hence to find the total number of foot-pounds we must measure the total force in pounds and the distance in feet, and multiply the two together. In the case of a common steam engine the total force is the total mean load on the piston, and the distance will be twice the length of stroke multiplied by the number of revolutions per minute. If p denotes the mean effective pressure per square inch, as found from an indicator card, and A is the area of the piston in square inches, then the product $p \times A$ is the total mean load. Also if L denotes the length of stroke in feet and N the number of revolutions per minute, then $2 \times L \times N$ is the distance in feet per minute, and the product of all these factors, or $2 \times L \times N \times p \times A$, will be the total number of foot-pounds of work per minute. This divided by 33,000 will then give the horse-power. As usually written this gives the common formula:

$$\text{Horse-power} = \frac{2\,pLAN}{33{,}000}$$

Horse-Shoe—In one of the forms of thrust bearing the rings or collars on which the thrust is taken are somewhat like a horse-shoe in form. They are provided with ears or projections at the sides, by means of which they are carried on heavy bolts at the sides of the bearing casing. Their adjustment on these bolts is controlled by nuts, and thus each horse-shoe may be so adjusted as to take its share of the thrust, or if any of them should become unduly heated, they may be slightly backed off and thus relieved of their load, and the danger of damage avoided.

Hot-Well—The chamber or space into which the air-pump delivers the water drawn from the condenser, and from which the feed-pumps take their supply for the boilers.

Hub—The central part of a screw-propeller to which the blades are attached, and which serves thus to unite them and to connect them with the shaft from which they receive their motion of rotation. The same term is used generally in referring to the metal about the shaft-hole of any rotating piece which turns upon or is carried by a shaft.

Hydraulic—The term *hydraulic* is used in referring to various forms of mechanism or appliance in which the moving force is derived from liquid under pressure. Strictly speaking, the term should only be applied when water is the liquid used, but by common usage it is employed no matter what the liquid, which may be either water, oil, or, very commonly, a mixture of water and glycerine.

Hydropmeter—An appliance placed in the bottom of a fire-tube boiler and used to promote a circulation of water, especially when getting up steam from cold water. It consists of a series of nozzles, one within the other, and its mode of operation is similar to that of a *bilge siphon* (see Fig. 5), the steam required being led from another boiler under the necessary head of steam.

NEW PUBLICATIONS.

KNOW YOUR OWN SHIP. By Thomas Walton. Fourth edition greatly enlarged; 1899. Chas. Griffin & Co., London; J. B. Lippincott Co., Philadelphia. Size, 5 3-4 by 8. Pages, 336. With numerous drawings. Cloth. $2.50.

This book, which forms one of *Griffin's Nautical Series*, is written primarily for shipowners, ship's officers and sailor folk in general, rather than for the naval architect or shipbuilder. To all interested as the above classes are, it is intended to give elementary and simple, yet accurate, ideas of the construction of ships and their principal nautical qualities, including stability, strength, oscillations, tonnage, freeboard, etc. The book is divided into eight chapters, as follows:

Chapter I explains in simple language and by the aid of suitable diagrams what displacement is, its equality with the weight of the ship, and its dependence on the form and dimensions of the ship as shown by the block coefficient.

In Chapter II an elementary explanation is given of the principle of moments, and of its application to the problem of shifted weights.

In Chapter III the equality of the buoyancy and weight is shown, and the loss of buoyancy due to bilged compartments is discussed, as well as the change in the distribution of the buoyancy when the ship either inclines or changes trim.

Chapter IV deals with the causes of stress on the structure of the ship, and especially as to its dependence on variations in the loading and in the distribution of the water ballast.

Chapter V takes up in some detail the construction of the ship and discusses the leading features with an explanation of Lloyd's numerals and their use in determining the various scantlings. Special features, such as engine foundations, shaft-struts, etc., are also given some attention.

Chapter VI is divided into a number of sections, dealing with stability in general, rolling, ballasting, loss of stability due to bilged compartments, relation of stability to sail area, etc.

Chapter VII deals with the subject of tonnage, and shows its importance to the shipowner from the economical point of view. The cases commonly arising are discussed, and the various deductions, etc., are explained in detail.

Chapter VIII deals similarly with the subject of freeboard, and the book closes with a collection of test questions, and an appendix giving some further discussion on the subject of rolling and dynamical stability.

The topics treated in the book show excellent judgment in the selection, and are such as every shipowner and officer should be familiar with. The treatment also is simple and clear, and avoids technicalities which would only be of interest to the naval architect or shipbuilder. On the whole the book seems to be such as should realize in high degree the purposes of the author, and it may be warmly commended to all those who are interested in an elementary discussion of ships and their nautical qualities.

HEAT AND HEAT ENGINES. *A study of the principles which underlie the mechanical engineering of a power plant.* By Frederick Remsen Hutton, Columbia University. First Edition, 1899. John Wiley & Sons, New York; London, Chapman & Hall. Size, 6 by 9 1-4. Pages, 553. Profusely illustrated. Cloth, $5.00.

In this book we find the subject of thermodynamics and its applications to heat engines presented in an elementary manner, and as far as possible without the aid of calculus and higher mathematics. The book is intended as a natural sequel to the same author's earlier work on *The Mechanical Engineering of Power Plants.* The purpose in the earlier work was to present a general discussion of steam engines, boilers and accessory apparatus as found on the market and ready for selection by the power plant designer. No attempt was made, however, to discuss the questions involved in the design of such apparatus, and to quote from the author's preface to the present work:

"It was intended that the student should ask at the end of his study of that book: What are the principles of physics and dynamics upon which these machines depend; and how do engineers proceed when called upon to design such power-house engines? This book has been prepared to answer these questions in part. It discusses the energy resident in fuels, and the methods of its libcration as heat for power purposes; the transfer of such heat to convenient media whereby it can be used in heat-engines; the laws and properties of such media, and the design of cylinders of the necessary volume to give a desired mechanical effect or horsepower."

The mode of treatment adopted renders the development of the subject somewhat less logical and complete than might have been the case with the use of higher mathematics. This is fully realized by the author, who expresses the hope that the student will turn from the present work to further research in the higher field.

In general the subject matter of the book is well selected, and it is presented in a clear and instructive manner. The chapters on the steam engine give a good discussion of the theory of the engine, and a clear statement of the various losses to which the operations are subject, and the various means available for reducing or preventing them.

The book is well provided with diagrams and cuts, most of which seem to have been specially prepared for this work.

A brief bibliography is given in an appendix, in which the more important works in this field are noted. This for the student is a very useful feature, as he may here find references to the important literature of the subject, and may use it as a guide in his further studies in this field.

NOTES ON THE CONSTRUCTION OF CRANES AND LIFTING MACHINERY. By E. C. R. Marks. New and enlarged edition, 1899. Technical Publishing Co., Manchester; D. Van Nostrand & Co., New York. Size, 5 by 7 1-2. Pages, 183. With 155 illustrations. Cloth.

This book contains in some twenty-six chapters brief descriptions of the more common forms of lifting ma-

chinery, from the simple pulley block and plain crab to the more complicated forms of traveling crane and conveying apparatus.

The subject of hand-power hoisting machinery is first taken up, and the ordinary forms of rope pulley, hand crab, derrick, pillar and jib-crane, etc., are described and a brief discussion is given of the principles entering into the design of such machines, both as regards the proportions of the parts in order to fulfill the general purposes in view, and also as regards the dimensions necessary to safely carry the stresses to which they may be subject.

Passing next to power-driven machinery, the various forms of steam-driven hoists and cranes, both fixed and locomotive, are considered, and their essential features and structural arrangements are described. Good use is made here and elsewhere in the book of the principles of work and efficiency in discussing the relation of the capacity of the motor to the work to be done at the load end, and the relation between the speeds at the motor and at the load.

Mention is also made of warehouse elevators and cage lifts, the special subject of passenger elevators being only briefly touched on.

Overhead traveling shop cranes are next taken up, and the square shaft and rope-driven varieties are described, with brief mention of the electric crane. The latter type, which in the United States has almost completely driven other types from the field, is here disposed of in one-half page. In the last chapter, added as a feature of the present new edition, a few brief descriptions, taken mostly from patent specifications, are added relative to electric hoists. The lack of information relating to electric hoisting machinery is a defect in the book from the standpoint of the American reader, who would doubtless prefer present practice to a discussion of types which are here obsolete. The book is also incomplete in its discussion of the general problem of handling and transportation by machinery. The developments in the United States which have led to the systems for handling and transporting shipbuilding material, etc., to be found in most of our leading shipyards, or to the systems for loading and unloading ore, coal, grain, etc., especially at the chief lake ports, receive no attention. While the book is written presumably to cover British practice, it would surely be of more interest and value to its home readers if some notice were given of these systems of handling and transportation which are capable of accomplishing such astonishing results. From the standpoint of British practice, however, the book seems to fairly cover the field, and to give in a plain and readable style good descriptions of most of the forms of apparatus in common use.

The book is well provided with illustrations, most of which appear to be drawn to scale, and thus to give good ideas regarding the general proportion as well as the arrangement of the various parts.

Small Engines and Boilers. *A manual of concise and specific directions for the construction of small engines and boilers of modern types, from 5-horse power down to model sizes for amateurs and others interested in such work.* By Egbert P. Watson. D. Van Nostrand Co., New York. 1899. Size, 5 3-4 by 8 1-4. Pages, 108. With 30 working dimensioned drawings. Cloth, $1.25.

This book is intended chiefly for amateurs and students, on the assumption that those who need a guide of this kind have some acquaintance with ordinary machine work. The plans of the different size engines and boilers are carefully drawn, and have correct dimensions, and are so designed that they may be built with a limited number of small tools and still be mechanical jobs. The work contains hints on lathe work, vice work and finishing metals, which will be of service to those who have but a limited experience. The author lays particular stress on good workmanship in comparison with the tinker work which is too often employed in making working models. Several of the engines and boilers described are of sufficient size to drive a small boat or shop.

The Slide Valve Simply Explained. By W. J. Tennant. Revised and much enlarged by J. H. Kinealy, D.E. Spon & Chamberlain, 12 Cortlandt St., New York. 1899. Size, 5 by 5 1-2. With 41 original illustrations. Cloth, $1.00.

This work is based on notes and diagrams which were prepared by the writer originally to help his railway students toward the obtainment of clear general notions upon the important subject of the slide valve. Instead of using the complicated valve diagrams and formulæ he has endeavored to simplify the matter by a system of cardboard diagrams in which the successive positions of valve and crank can be closely followed. All the different working conditions of valves and effects of alterations to the same are discussed. The book is nicely illustrated, and different styles of modern valves are shown and their action described.

War History Monograph. *Part 26. The fighting about Candia between 1667-1669.* By Biggie. Issued under the authority of the German General Staff. Ernst Siegfried Mittler & Sons, Berlin, 1899. Pages, 114. With maps and plans.

This monograph is one of a series of war papers issued by the German General Staff, and deals with one phase of the long struggle between Venice and the Turkish power in Europe. While this war was chiefly naval, its interest is now, of course, historical rather than present day. The war ships in vogue in those times—the galley and high-sided sailing ship—are described with special reference to their use in the naval operations there carried on. The various features of the different campaigns are described with seemingly accurate and painstaking detail, while the maps and plans give additional aid in following clearly the descriptions of the text. The student of naval history should find in this monograph much of interest and value.

A very artistic souvenir of the participation of the American line ships in the Hispano-American war has been gotten out by the management. It consists of a paper-covered pamphlet richly illustrated with original drawings, sketches and photographs depicting scenes on and off the vessels *St. Paul, St. Louis, Harvard* and *Yale.* In the accompanying text the services of each vessel are recorded, together with a complete roster of the crews.